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**Niemiec et al.**

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(54) **CEILING TILE WITH BUILT-IN AIR FLOW MECHANISM AND UV AIR PURIFYING DEVICE**

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F21S 8/061 (2013.01); F21V 29/67 (2015.01);  
F21V 33/0096 (2013.01); F24F 3/16  
(2013.01); F24F 13/078 (2013.01); F05D  
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Oct. 11, 2018, now Pat. No. 10,316,141, which is a  
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(51) **Int. Cl.**

**C08G 63/672** (2006.01)  
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**F04D 25/08** (2006.01)

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(58) **Field of Classification Search**

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F21K 9/278; F21Y 2115/10; F21V 29/00;  
F21V 29/002; F21V 29/02; F21V 29/20;  
F21V 29/40; F21V 29/50

See application file for complete search history.

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*Primary Examiner* — Joseph L Williams

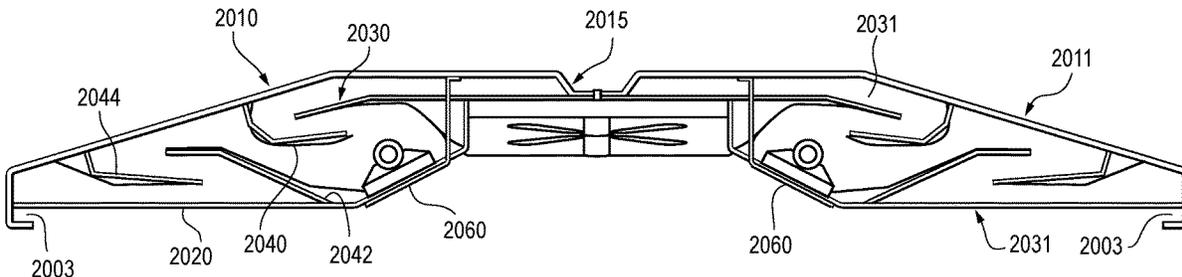
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Gasey LLP

(57) **ABSTRACT**

Disclosed embodiments relate to a combination axial fan and LED lighting system configured to fit into the footprint of a standard ceiling tile. Disclosed embodiments further include ceiling tiles with a built-in fan and/or LED lighting. The disclosed systems may include a housing container and an axial fan. The fan has a fan cavity including air diversion mechanism to direct air from the fan cavity toward the lighting and fan components. The inventions include an airflow surface to direct air existing the fan cavity along an LED light fixture. Moreover, disclosed embodiments include one or more UV light sources which irradiate contaminants as air flows through the ceiling tile.

**20 Claims, 23 Drawing Sheets**



**Related U.S. Application Data**

continuation-in-part of application No. 16/040,189, filed on Jul. 19, 2018, now Pat. No. 10,221,857, which is a continuation-in-part of application No. 15/589,367, filed on May 8, 2017, now Pat. No. 10,247,191, which is a continuation-in-part of application No. 15/471,762, filed on Mar. 28, 2017, now Pat. No. 10,006,619.

(60) Provisional application No. 62/439,719, filed on Dec. 28, 2016.

(51) **Int. Cl.**

<i>F21V 33/00</i>	(2006.01)
<i>F21S 8/02</i>	(2006.01)
<i>C08G 81/00</i>	(2006.01)
<i>F24F 13/078</i>	(2006.01)
<i>F24F 3/16</i>	(2021.01)
<i>F21S 8/06</i>	(2006.01)
<i>F21V 29/67</i>	(2015.01)
<i>F21Y 115/10</i>	(2016.01)
<i>F24F 13/068</i>	(2006.01)
<i>F24F 13/08</i>	(2006.01)
<i>F24F 8/22</i>	(2021.01)

(52) **U.S. Cl.**

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(2013.01); *F24F 2221/14* (2013.01); *Y10S*  
*525/905* (2013.01)

Fig. 1

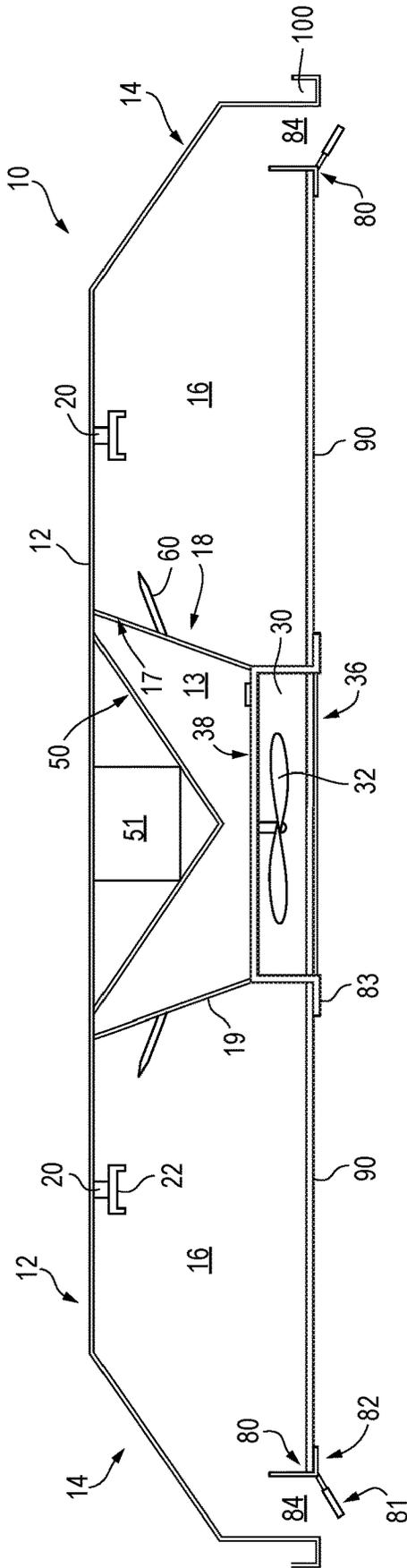


Fig. 2

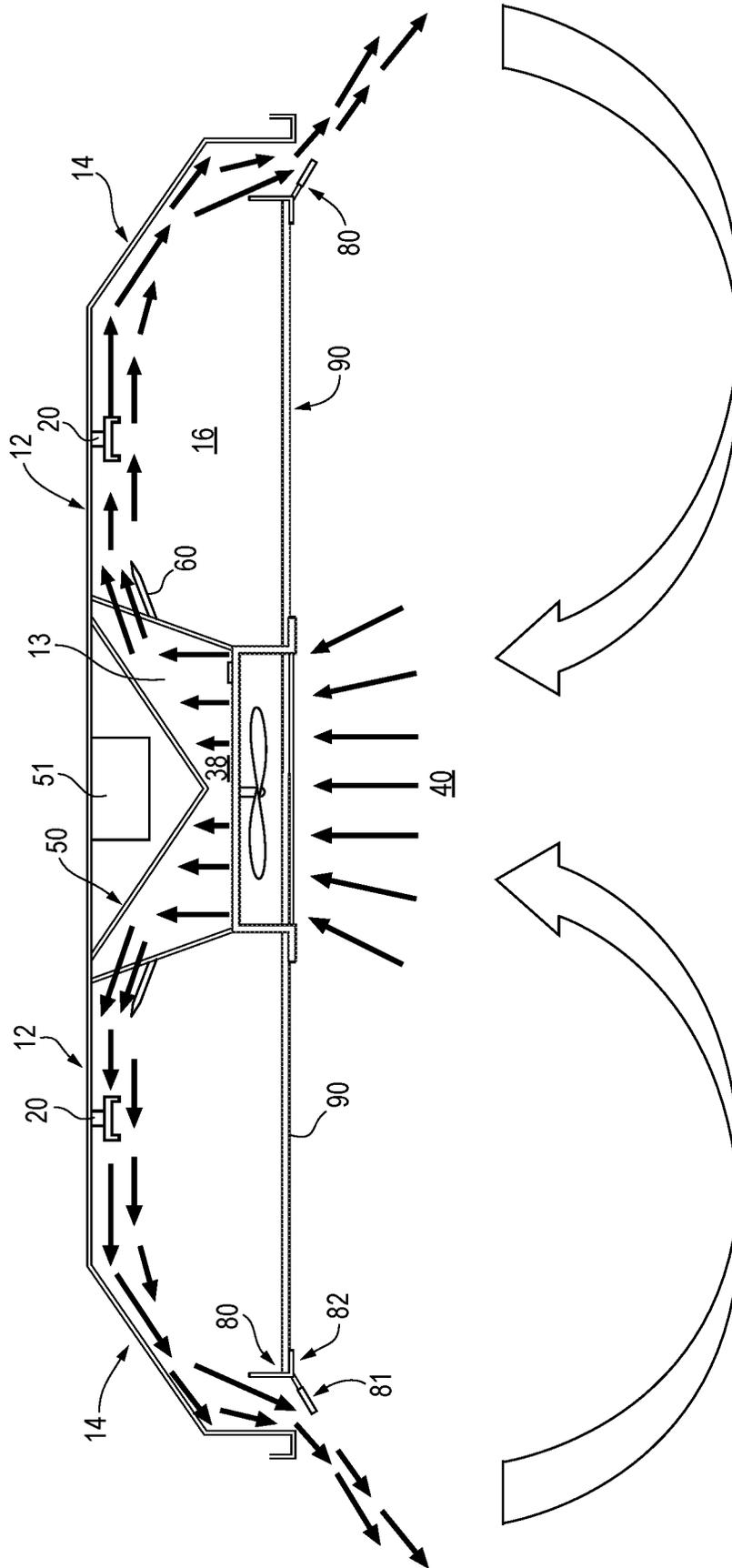


Fig. 3

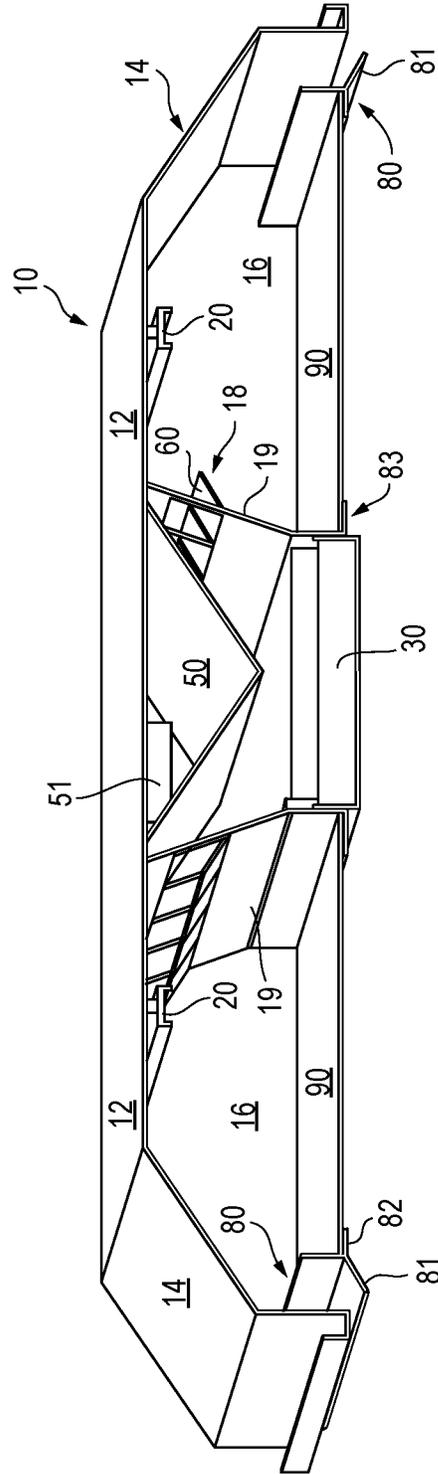


Fig. 4

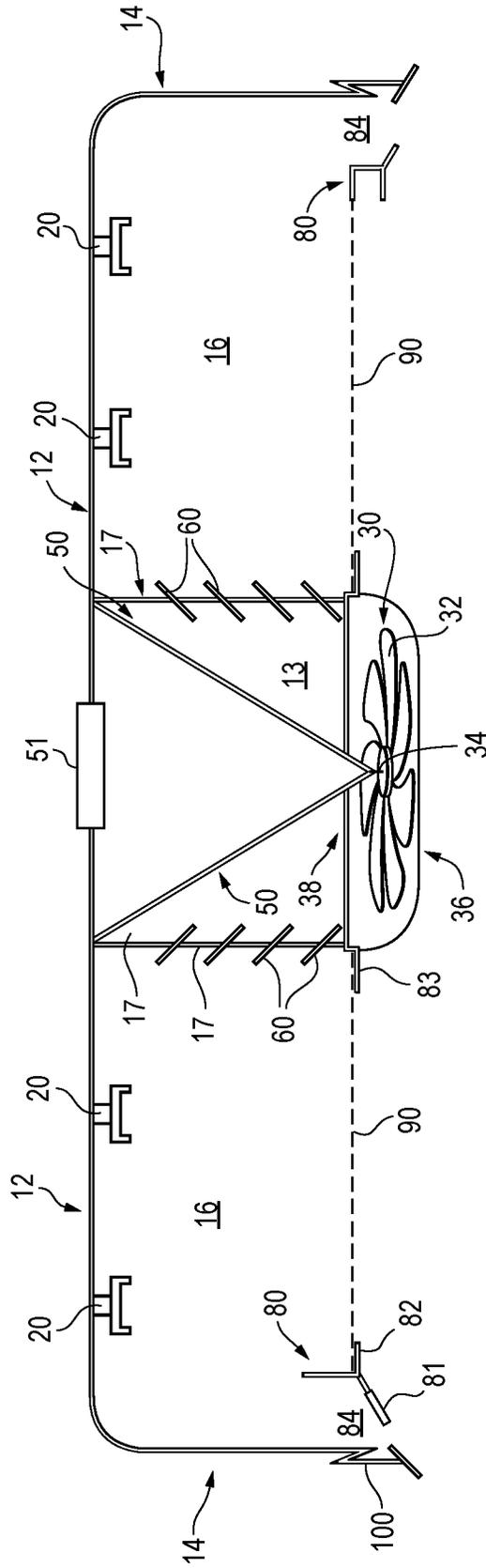


Fig. 5

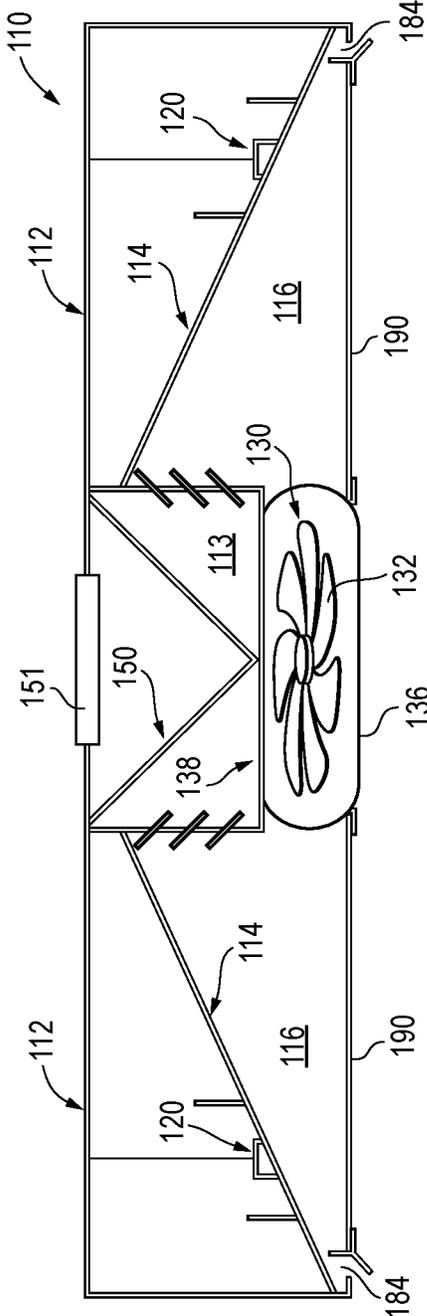


Fig. 6

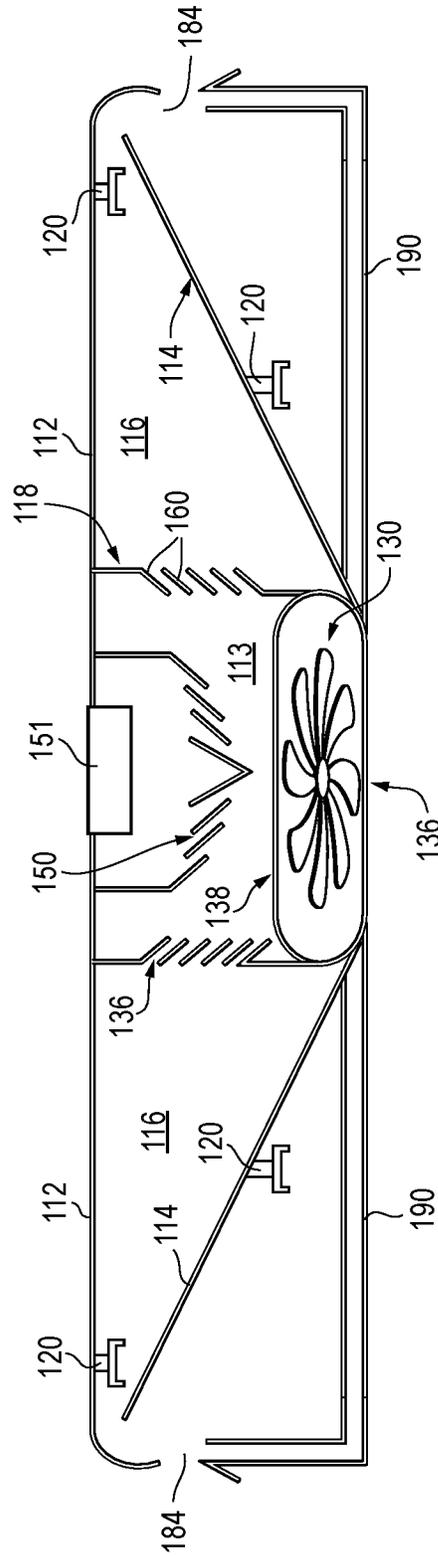
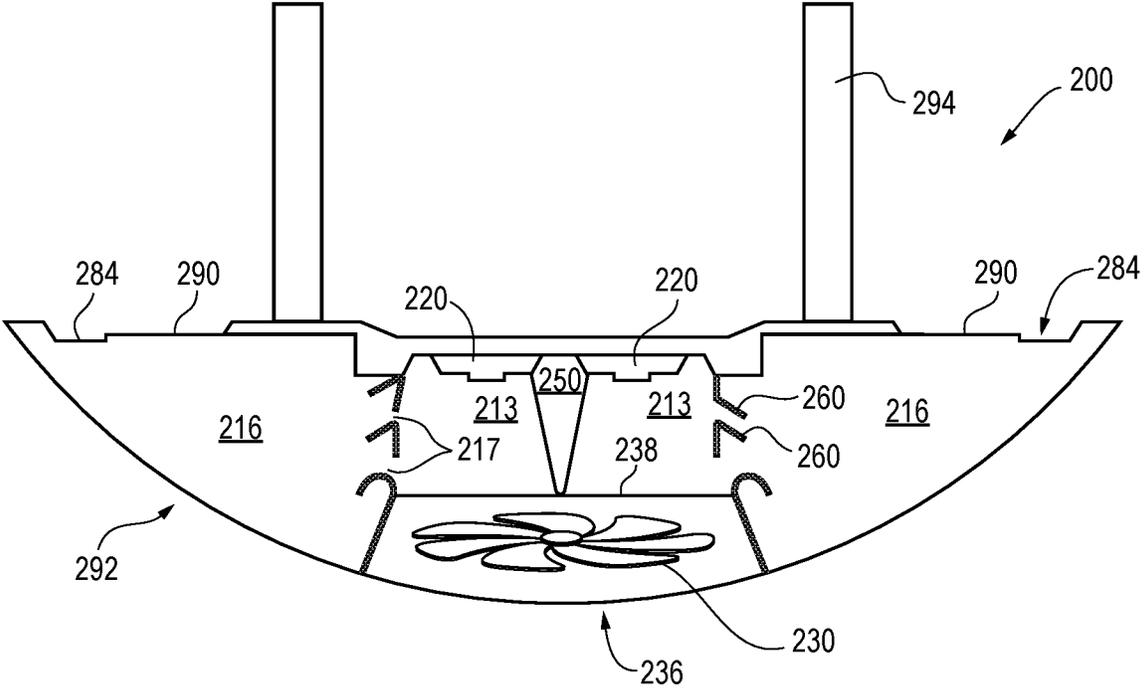


Fig. 7



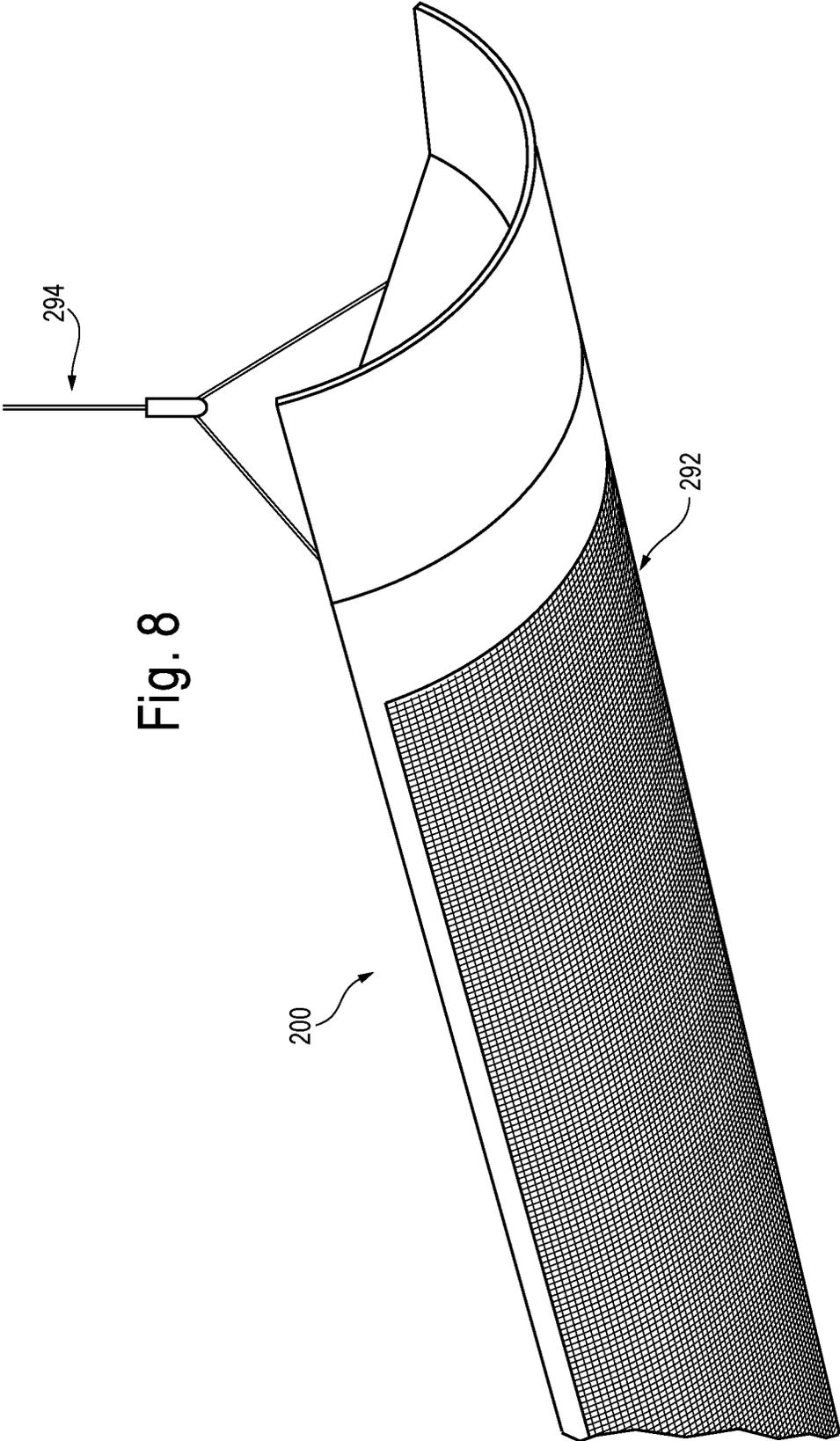


Fig. 8

Fig. 9

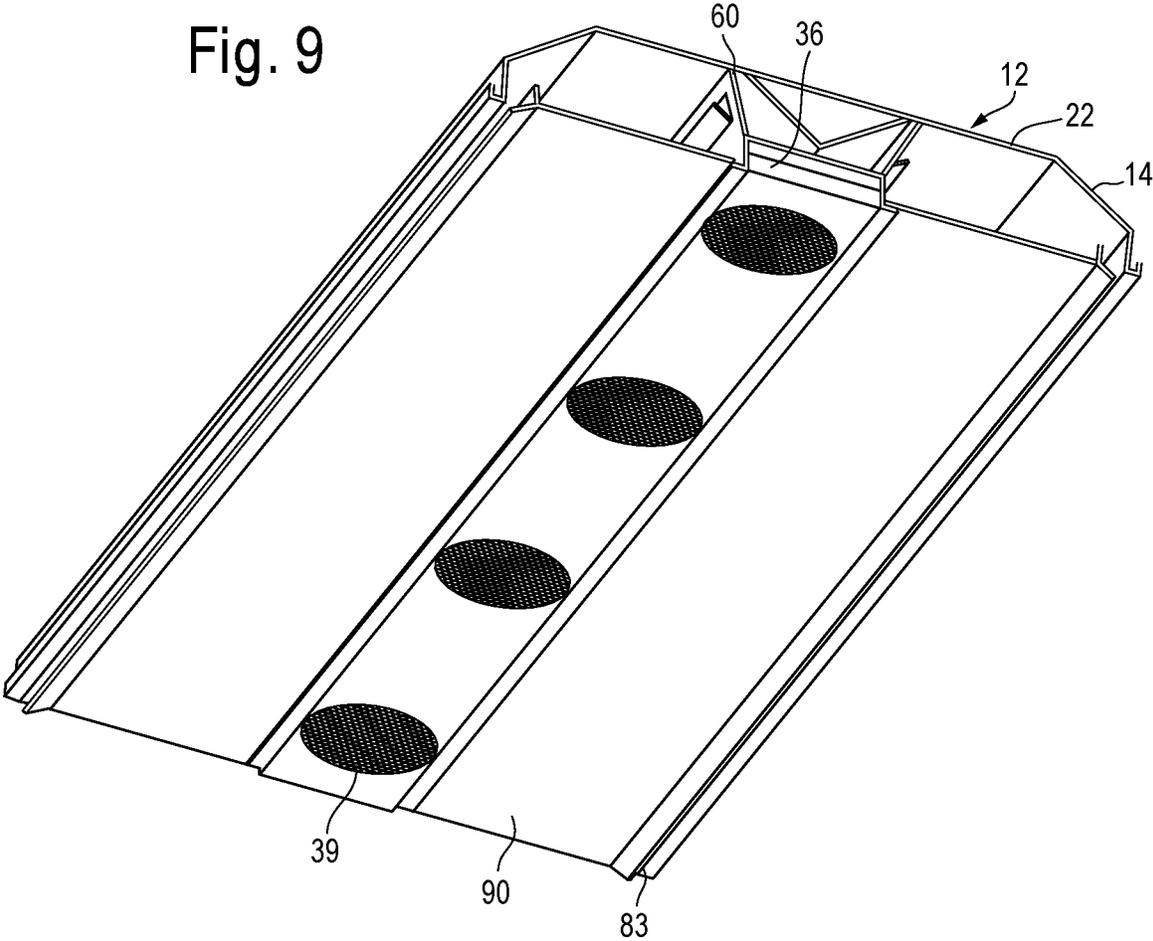


Fig. 9A

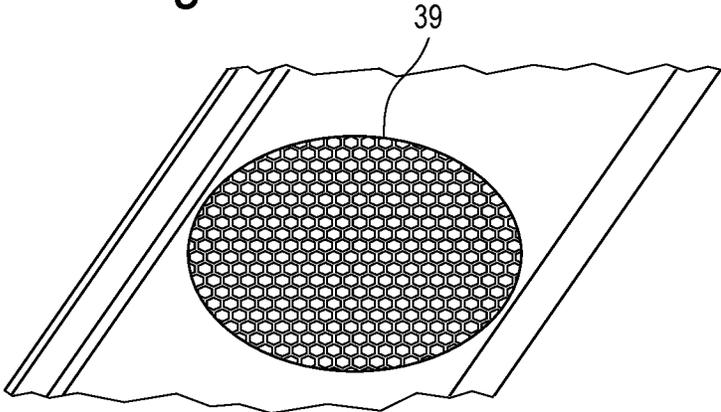


Fig. 10

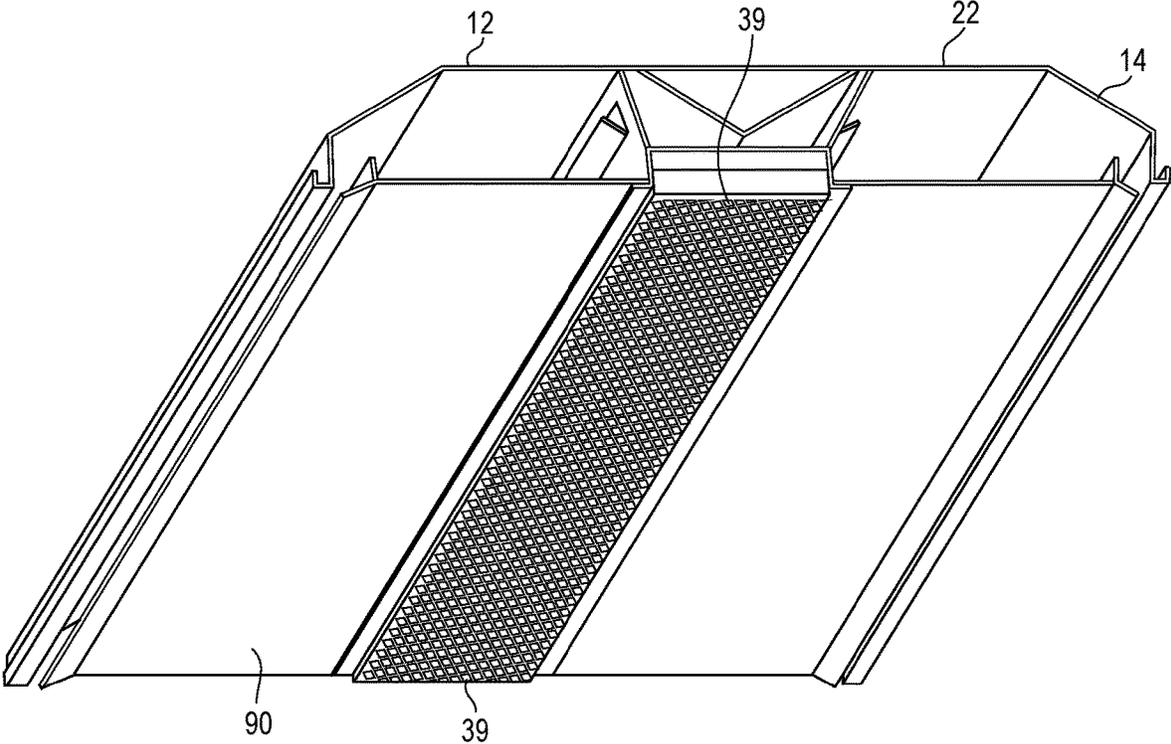


Fig. 10A

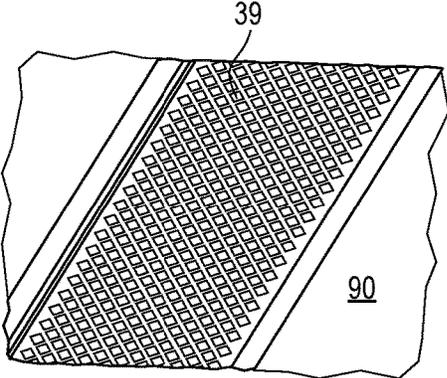


Fig. 11

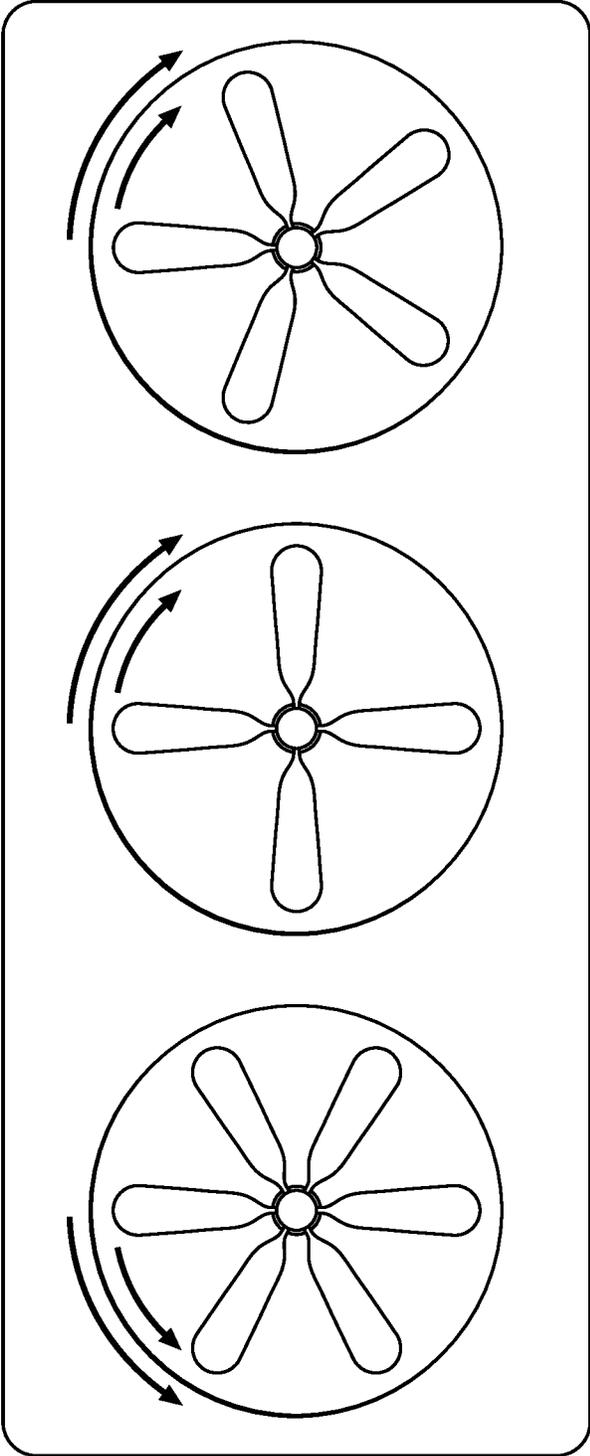


Fig. 11A

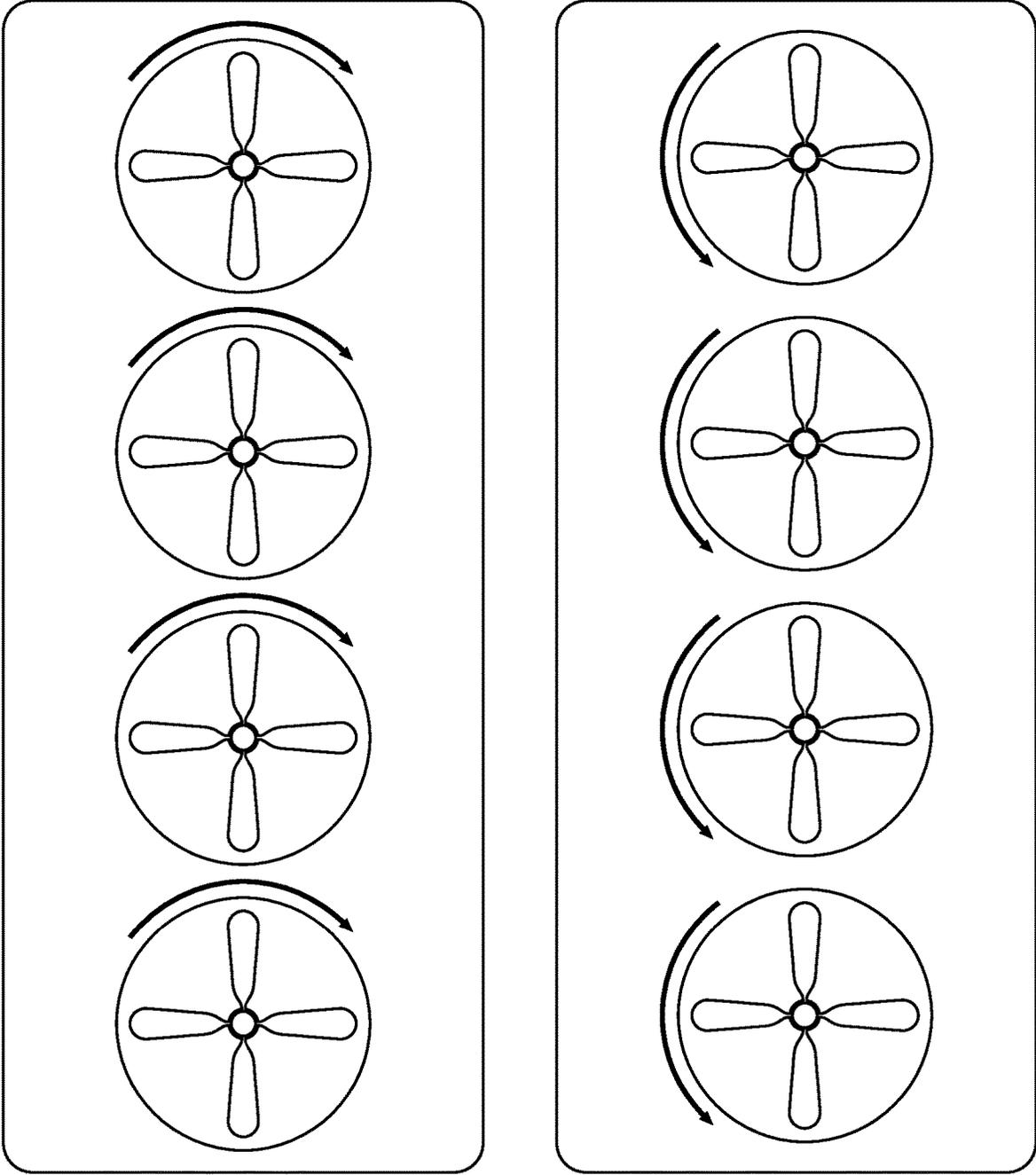


Fig. 12

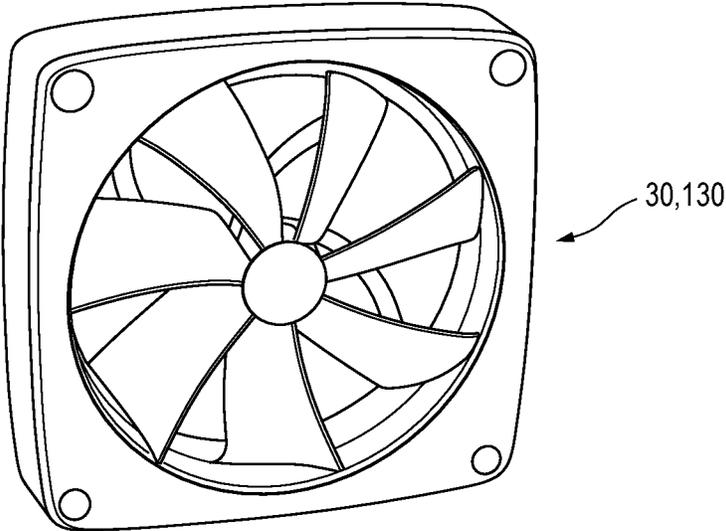


Fig. 13

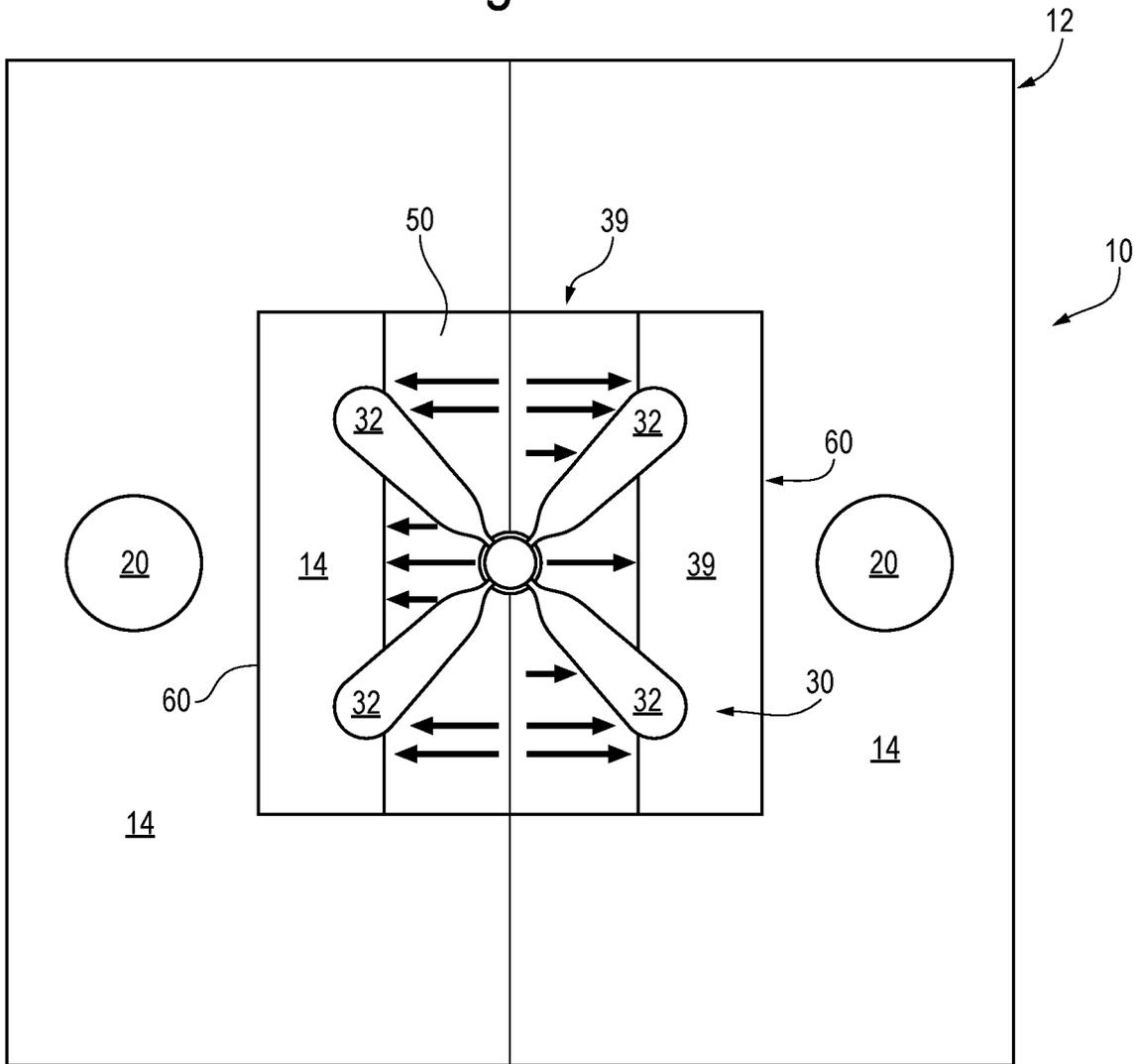


Fig. 14

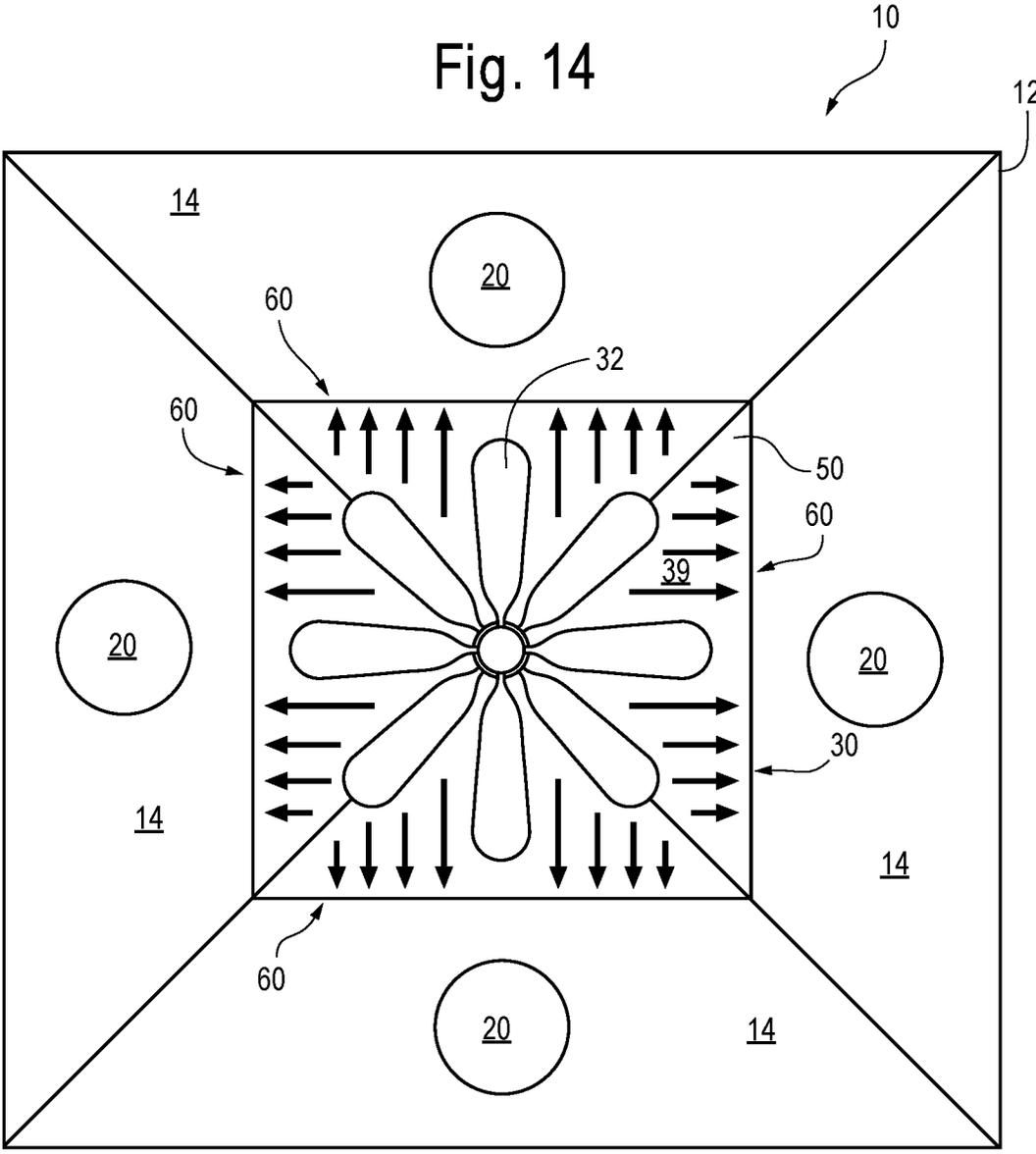


Fig. 15

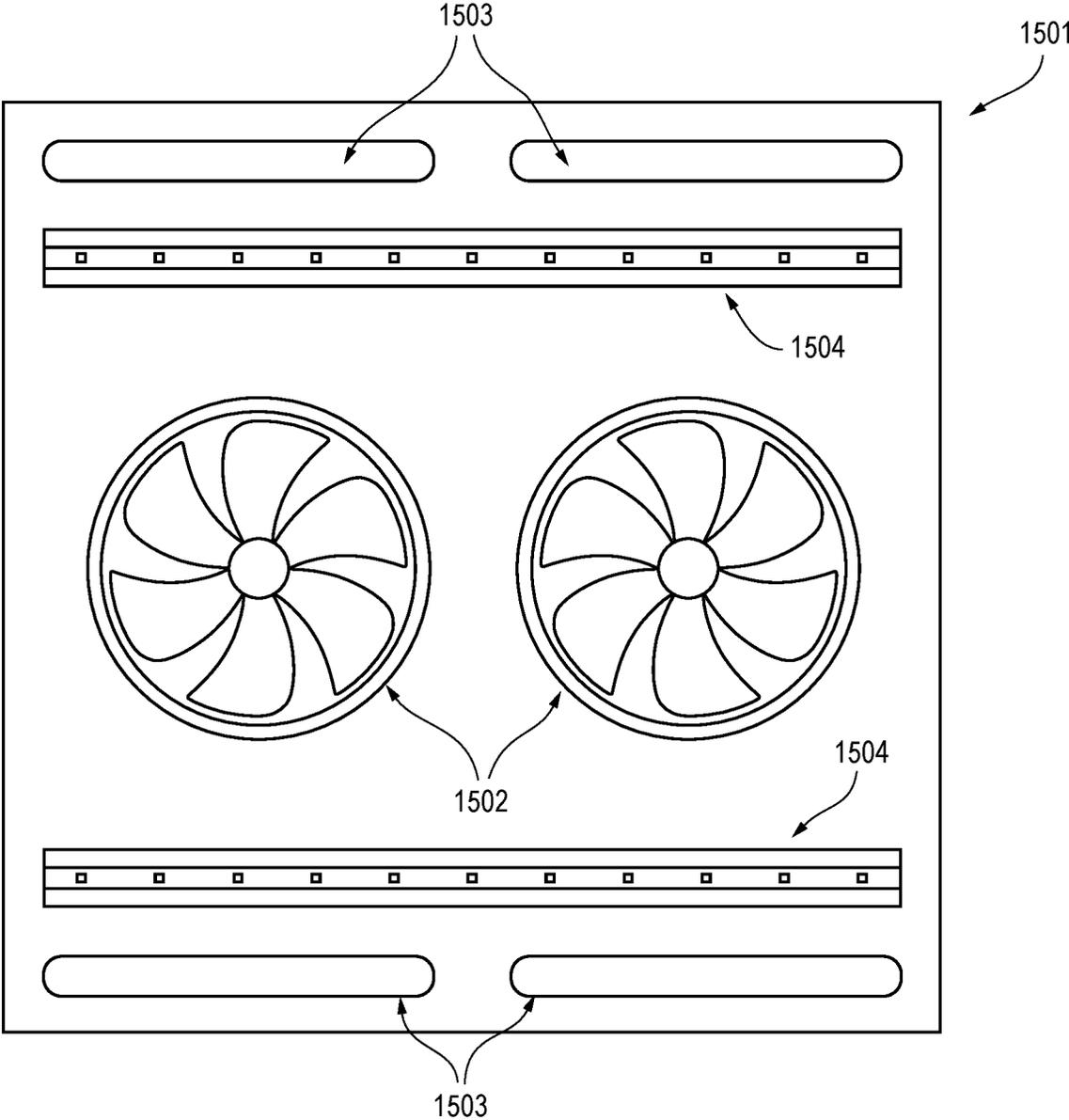


Fig. 16A

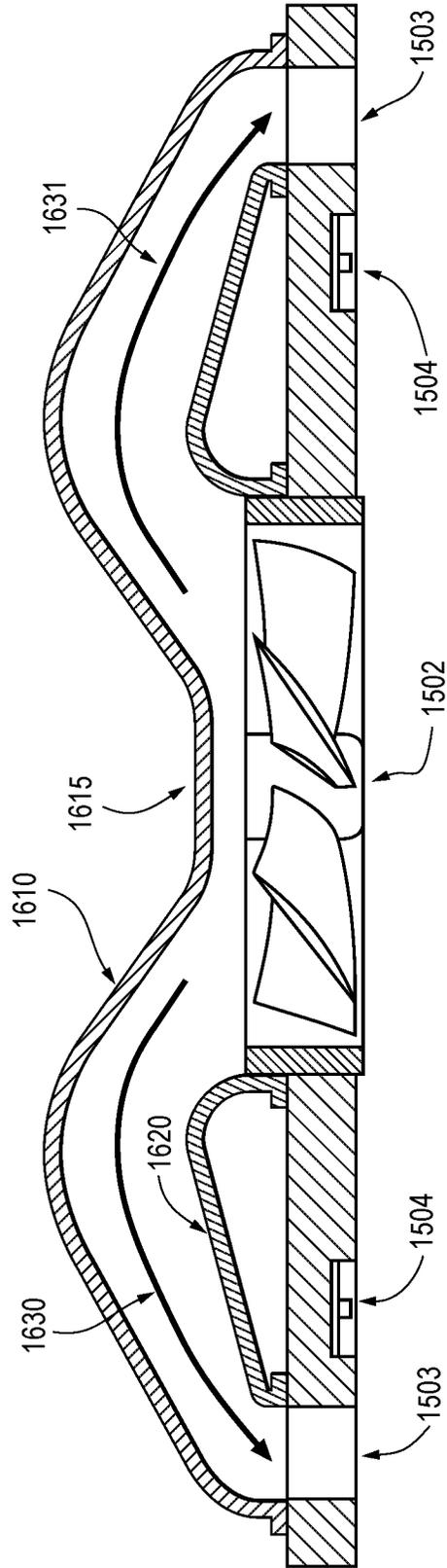


Fig. 16B

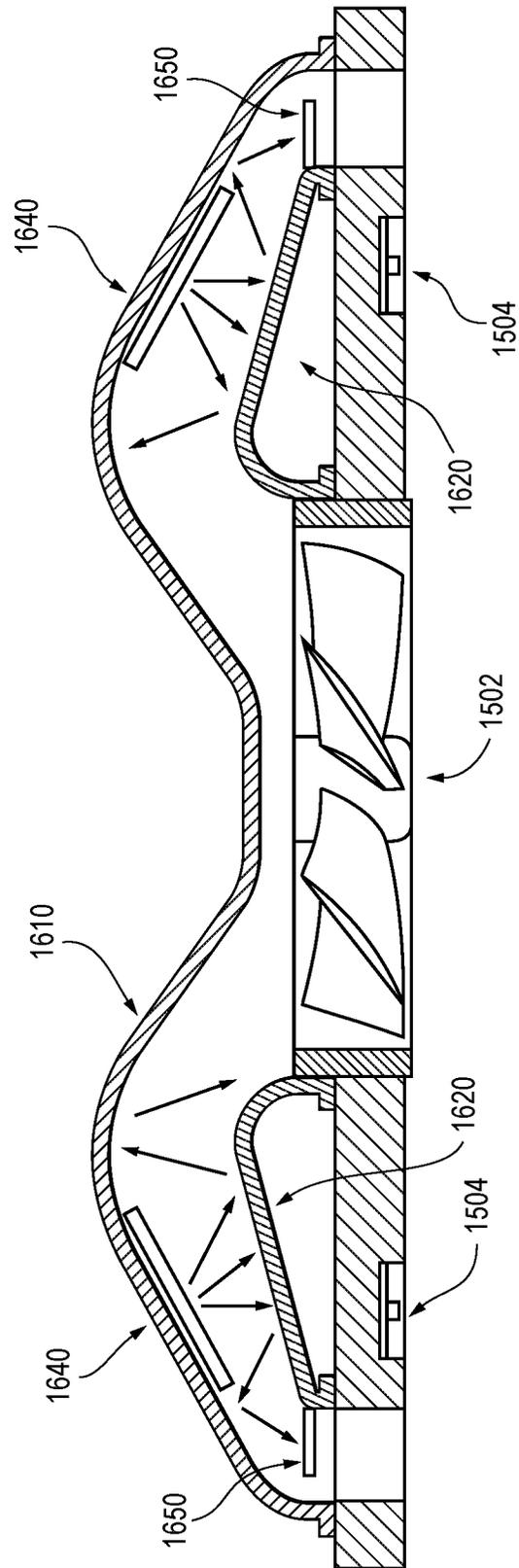


Fig. 17

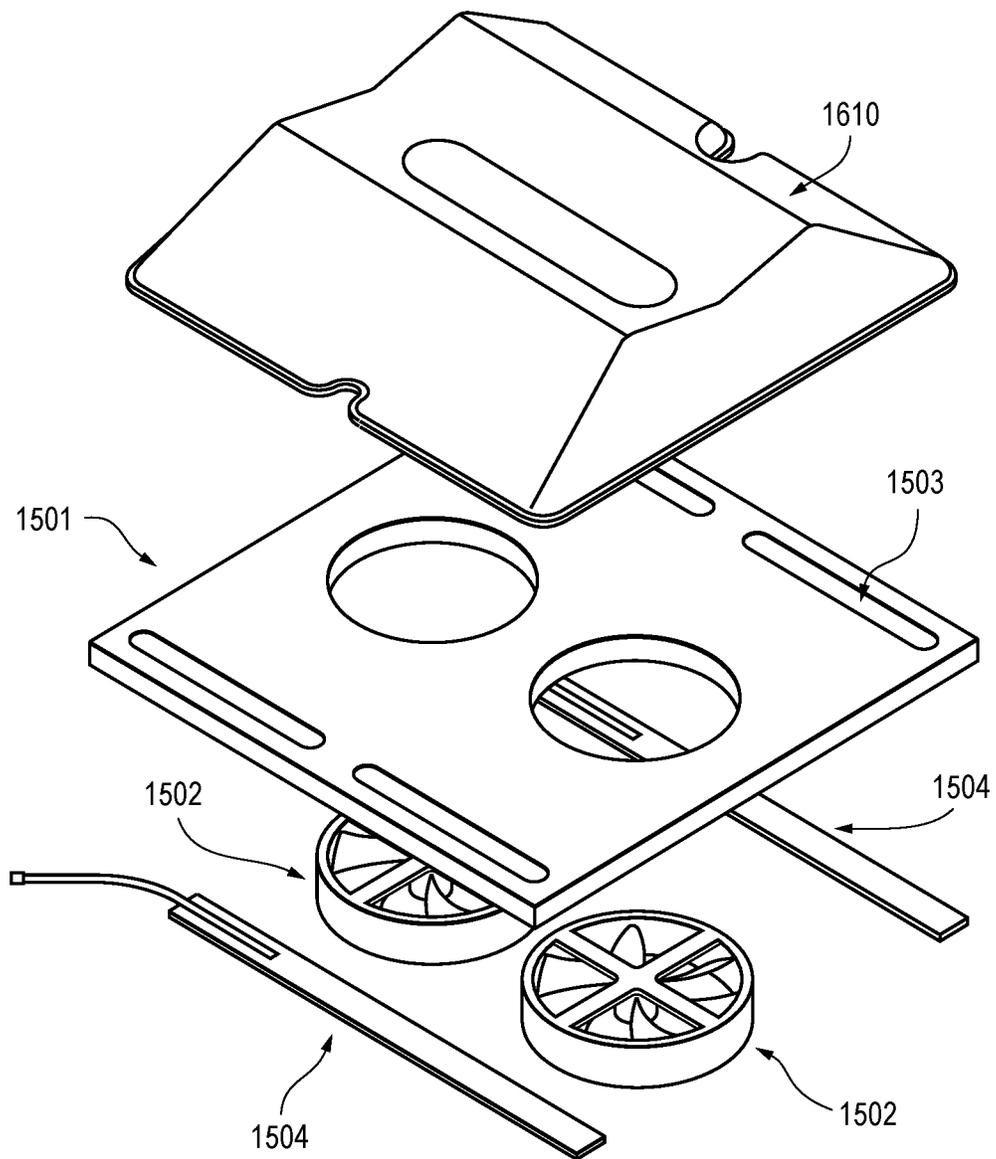


Fig. 18

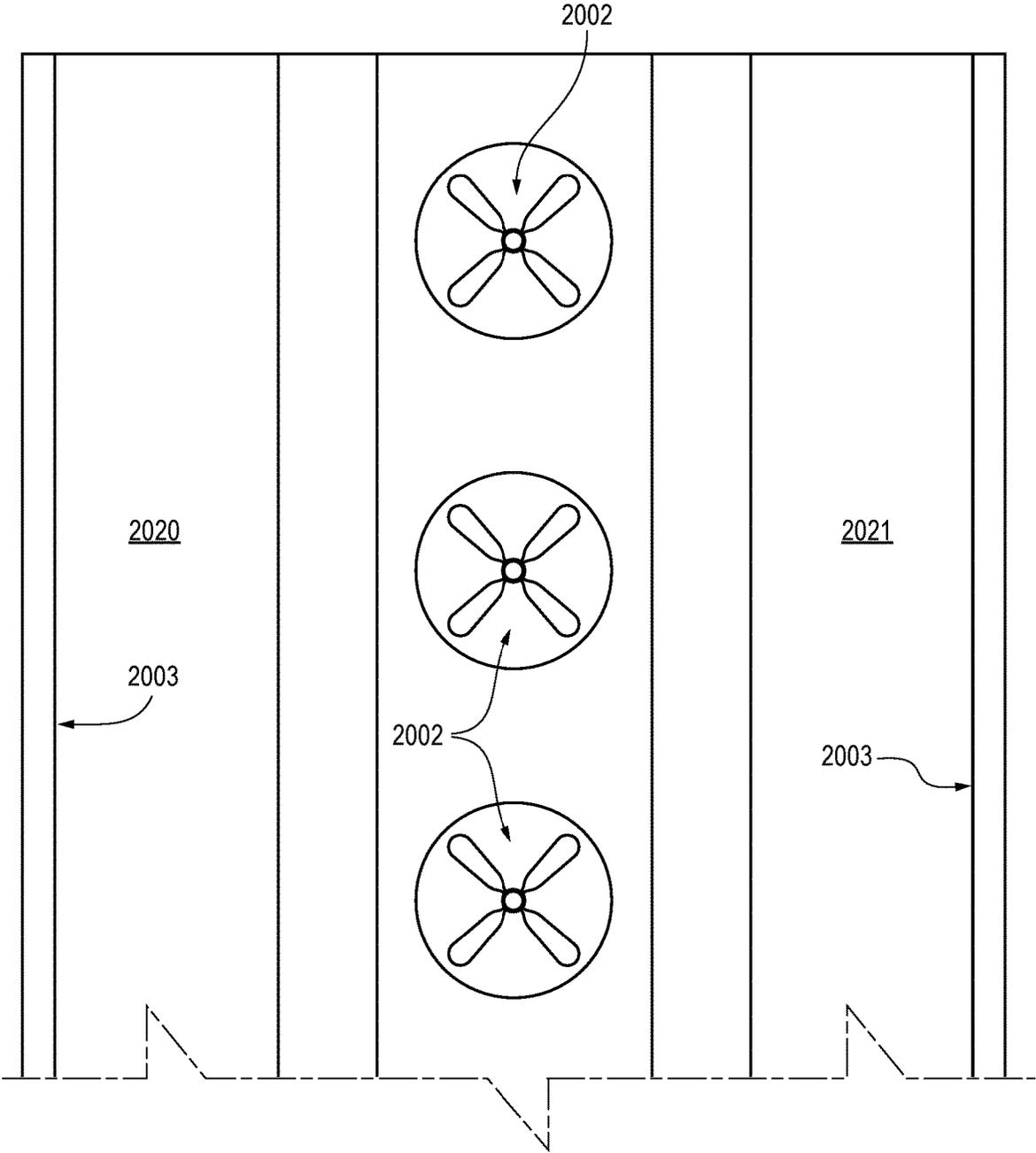


Fig. 19

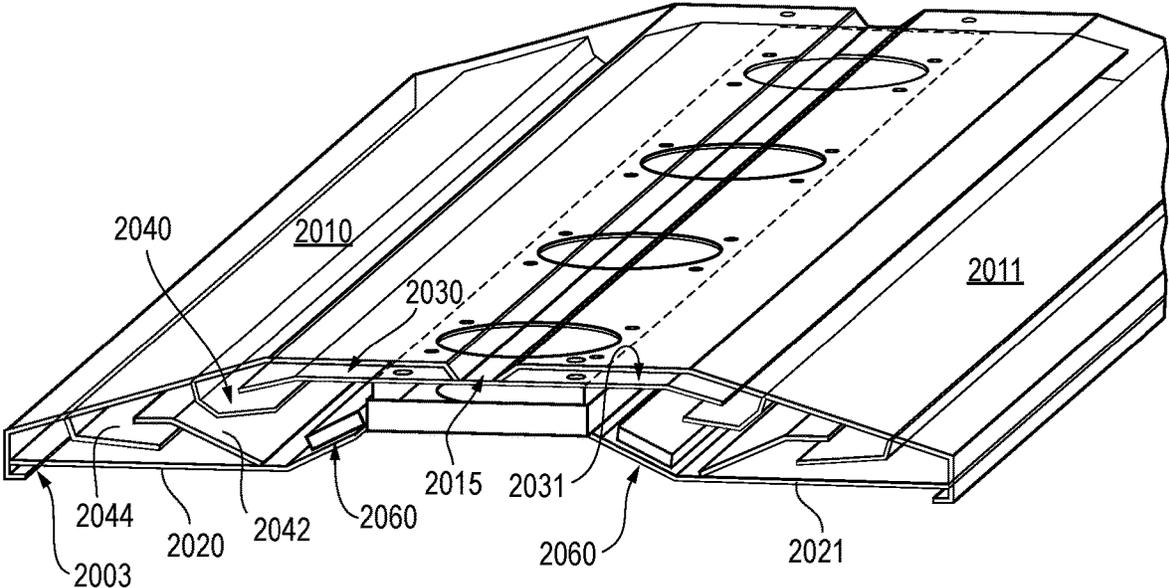


Fig. 20A

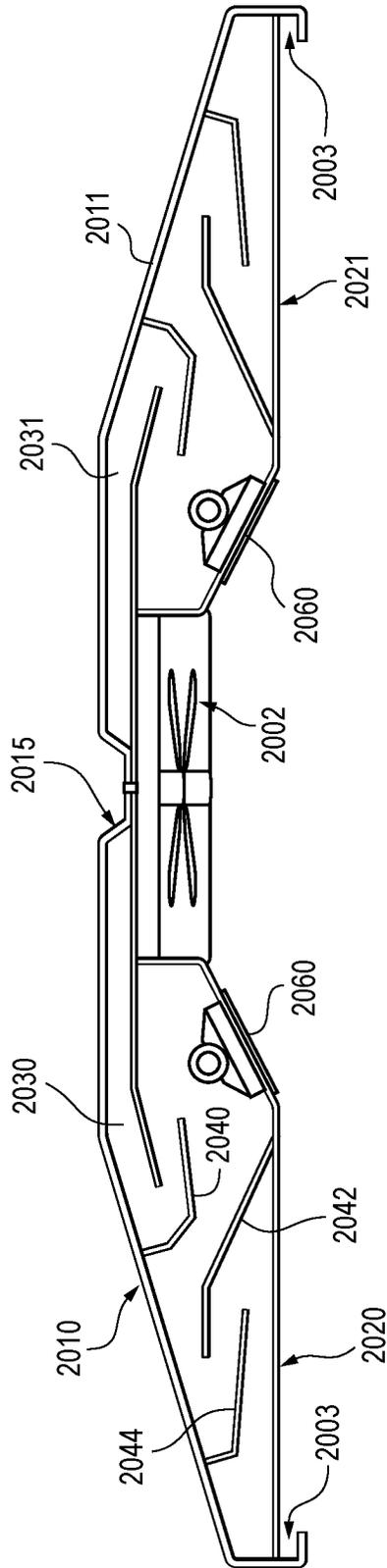
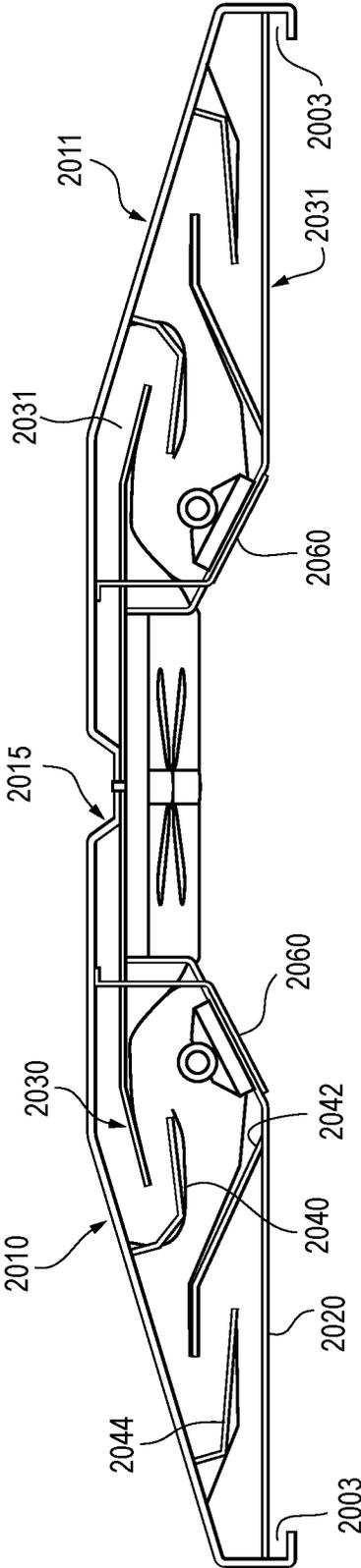


Fig. 20B



## CEILING TILE WITH BUILT-IN AIR FLOW MECHANISM AND UV AIR PURIFYING DEVICE

This application is a continuation of application Ser. No. 16/157,874 filed on Oct. 11, 2018 which is a continuation-in-part of application Ser. No. 16/040,189, filed on Jul. 19, 2018, issued as U.S. Pat. No. 10,221,857, which is a continuation-in-part of application Ser. No. 15/589,367, filed on May 8, 2017, issued as U.S. Pat. No. 10,247,191, which is a continuation-in-part of application Ser. No. 15/471,762, filed on Mar. 28, 2017, issued as U.S. Pat. No. 10,006,619, which claims priority from Provisional Patent Application Ser. No. 62/439,719 filed Dec. 28, 2016.

### FIELD OF THE INVENTION

The present inventions relate to ceiling tiles with built in air flow mechanisms and optional LED lighting, for maintaining proper air quality and air movement in an indoor environment. Embodiments of the inventions further include a UV light source which decontaminates air as it flows through the ceiling tiles and thus helps prevent the spread of bacteria, fungus, viruses and/or mold, etc.

### BACKGROUND OF THE INVENTION

Indoor spaces such as offices, hospitals, retail stores, educational institutions and the like have two main issues: (1) maintaining proper air quality and air movement; and (2) providing adequate lighting. Indoor spaces often have only a single HVAC system that provides air and heat to all of the different sized offices or rooms within a space. Separately, the indoor space utilizes a series of LED lights that are mounted in ceiling tiles having a dimension of 2 ft.×2 ft. or 2 ft.×4 ft. There is a need for a system which can move air within an indoor space which supplements the primary HVAC system while at the same time providing ample lighting within the indoor space while fitting into the dimensions of a ceiling tile. The system also can provide a cooling effect on the LED lights to prolong the life-span of the lights.

According to the U.S. Department of Energy (DOE), more than 360 million troffers provide general lighting in commercial building interiors. With their standard dimensions of 2 ft.×4 ft., 1 ft.×4 ft. and 2 ft.×2 ft., these luminaires are popular in dropped, acoustical-tile ceilings with a low ceiling height (less than or equal to 9 feet). The installed troffer base is predominantly linear fluorescent. In recent years, the development of LED technology has resulted in a broad selection of products designed to challenge fluorescent, offering up to 70 percent energy savings, longer life and controllability.

There does exist a problem with LED lights. Excessive heat causes damage to LED lights. LED bulbs that produce white light typically generate excessive heat that must be conducted away from the LED light system. Proper thermal management is critical to maintaining the original brightness and extending the lifespan of LED lights. Unfortunately, due to component costs, many manufacturers do not include the materials or structures necessary to provide proper heat transfer, thereby reducing the performance of the product. For example, most LED lighting manufacturers use less expensive and less reliable circuit boards that do not transfer heat well. Heat build-up in LED lights will damage the material, decrease the effectiveness of the light and decrease the lifespan of the lighting unit.

The secret to extending the useful life of an LED fixture is proper thermal management. There are several factors that affect the thermal performance of any fixture including the ambient air temperature, but LEDs specifically suffer from improper thermal design. The displacement of waste heat produced by LED lights is paramount to the longevity of the LED lights and can provide an advantage to a company in the emerging LED lighting industry.

The energy consumed by an incandescent bulb produces around 12% heat, 83% infrared radiation and only 5% visible light. A typical LED light produces 15% visible light and 85% heat. It is important to dissipate heat from LED's through efficient thermal management. The operating temperature of an LED light affects the lifespan of the LED. LED lights do not tend to fail catastrophically, instead the lumen output of the LED decreases over time. Elevated internal temperatures of the LED cause accelerated deterioration of the LED lights.

One of the major complaints levied by people working in an office, school, hospital, or commercial space concerns the temperature in the space. Complaints about temperatures are not just a matter of employees' preferences and tolerances. Temperature has been found to have a direct correlation to productivity. It is believed that productivity is linked to the temperature of the building. In addition to temperature issues within a building, employees may experience headaches, dizziness, nausea, irritation, cough, fatigue, asthma and other symptoms due to what has been termed "sick building syndrome." The primary sources of indoor air quality problems are believed to be inadequate ventilation and contamination from within the building.

Further, in an office or indoor environment, the absence of adequate ventilation causes irritating or harmful contaminants to accumulate, which causes worker discomfort, health problems and reduced performance levels. Such harmful contaminants include bacteria, fungus, mold or viruses that can cause people to become sick. There is a need for an air circulation mechanism which reduces airborne contaminants. Air purification is an important part of an HVAC system. A typical indoor HVAC system is not a substitute for source control or ventilation.

There is also a need to create what is called a virus or bacteria kill chamber. The kill chamber, or kill zone, must be self-enclosed such that any UV light source does not exit the kill chamber.

Moreover, it would be advantageous for an air circulation mechanism to fit within the footprint of a typical ceiling tile.

### SUMMARY OF THE INVENTION

The present inventions relate to a ceiling tile with a built-in fan for circulating air. Embodiments of the inventions may further include one or more LED strips for lighting the environment in which the ceiling tiles are installed. Further yet, embodiments of the invention may include one or more UV lights which irradiate the air flow, thereby removing airborne contaminants such as viruses, superbugs, mold, etc.

In some embodiments of the inventions, an air circulation device may comprise: a ceiling tile; at least a first fan mounted to the ceiling tile; a first vent in the ceiling tile; and a baffle, mounted to the ceiling tile, and defining at least a first airway between the fan and the first vent. A first LED strip may be mounted to the ceiling tile. Further embodiments may comprise at least a second vent, and a second LED strip, and wherein the baffle further defines a second airway between the fan and the second vent. The air circu-

lation may further comprise at least a second fan, wherein the first and second fan are configured in-line to direct air into the first and second airway. In some embodiments, the first and second fan are configured as air in-takes and air is exhausted through the first and second vent, and the first and second fan are configured to rotate in opposite directions.

Further yet, embodiments may include an air diversion mechanism configured to divert air from the first and second fan to the first and second airway. A first UV light source may be mounted in the first airway. In some embodiments, a second UV light source is mounted in the second airway. In some embodiments, the first and second airway are lined with a UV-reflective material. Moreover, the UV-reflective material may be stainless steel. The first and second UV light sources may emit UV-C light waves having a wavelength between 200 to 280 nanometers. The first and second UV light sources may be configured to be activated and deactivate via a remote control. The ceiling tile may be a drywall structure. In other embodiments, the ceiling tile is an acoustic panel.

The inventions include an air purifying device, comprising: a ceiling tile having at least one vent; a fan mounted to the ceiling tile; a baffle defining at least a first airway between the fan and the vent; and at least a first UV light source mounted in the first airway, wherein the first airway accommodates a UV-reflective material in at least a portion of the first airway; and wherein a first UV-screen is attached to the first airway to block UV light from exiting the airway.

In some embodiments, the air purifying device comprises at least a second vent, and wherein the baffle further defines at least a second airway between the fan and the second vent, wherein a second UV light source is mounted in the second airway, wherein the second airway accommodates a UV-reflective material in at least a portion of the second airway, and wherein a second UV-screen is attached to the first airway to block UV light from exiting the airway.

Further yet, in some embodiments the UV-reflective material creates a kill zone which decontaminates air flowing through the first and second airway. In some embodiments, a second fan mounted to the ceiling tile and in-line with the first fan. Some embodiments include an air diversion mechanism configured to divert air into the first and second airway. The first and second fan can be configured to rotate in opposite directions. The UV light source may be activated and deactivate remotely to decontaminate airflow through the first and second airway. In some embodiments, the UV light source is a UV-C light source having a wavelength between 200 to 280 nanometers.

The present invention further addresses the need to contain the light emitted from a UV-C light source within the chamber to create the kill zone. An extensive system of barriers are utilized within the kill chamber to create a kill zone while precluding the UV-C light from exiting the kill chamber. The baffles may be coated with a reflective material to enhance the effectiveness of UV-C light within the kill chamber.

The present invention combines the benefit of savings in electrical energy with savings in HVAC energy costs in one unit.

The present invention further includes the benefit of adapting the fan and LED lighting fixture to fit into the foot print of a ceiling tile to permit installation of the fixture in standard ceiling tile configurations, thus maintaining the aesthetics of the ceiling.

The present invention also includes the benefit of utilizing an ethernet or Wi-Fi (wireless) connection for remote control of the lighter and fan.

The present invention includes the benefit of moving air in an indoor space to provide more efficient heating of the indoor space.

The present invention may include the stepped fan blade technology of U.S. patent application Ser. Nos. 14/814,161, 15/043,923 and 15/346,913 which are all incorporated herein by references in their entirety. The stepped-fan blade technology provides the benefit of moving air through the fixture in a more efficient manner, thereby reducing the amount of energy required to operate the unit. The stepped blade technology also enables the fan to operate at a lower speed thus utilizing less energy and reducing noise. Finally, the stepped-fan blade technology disperses the air in a uniform manner.

The present invention provides the additional benefit of enhancing the life of all of the electrical fixtures (both the lighting and fan fixture) by reducing the amount of deterioration on each fixture caused by heat.

The present invention will also enhance the foot-candles per watt performance of the lighting optics by reducing the temperature of the LED light. The present invention reduces the problem of the LED light degrading over time due to an increase in temperature.

This design of the present invention will also enhance the ability to self-clean the lens on the LED face by utilizing air to push any dust or debris away from the lighting fixture.

This design of the present invention provides for a competitive advantage in that it permits electrical hook up in one complete unit that used to require two separate electrical connections, one for the fan and one for the light.

An added benefit of the present invention provides for a filter to clean the air that comes through the perforations of the intake or the screen of the light fixture—therefore creating a cleaner air environment.

The present invention may include the added benefit of connecting the light fixture to an HVAC system which introduces cooled or heated air into the fan of the light fixture to permit the cooled/heated air into the light fixture.

The present invention may utilize various color schemes to impact various behavior traits of a person. Color is believed to profoundly affect the productivity of a person. Research has shown that blue color is believed to affect a person's mind; yellow is believed to affect a person's emotions; red is believed to affect a person's body; and green is believed to affect a person's balance. Utilizing these colors in the present invention, the colors can affect a person's behavior. The colors scheme may be incorporated into the lens, the troffer shelf or the LED light.

Finally, the present invention presents a benefit of elimination of any strobing effect caused by the fan blades interfering with the light distribution.

These and other objects and advantages of the present invention, as well as the details of the illustrative embodiment, will be more fully understood from the following specification and drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional view of one embodiment of the combination light and fan fixture depicting a troffer shelf;

FIG. 2 is a sectional view of one embodiment of the combination light and fan fixture showing the flow of air;

FIG. 3 is a prospective view of one embodiment of the combination light and fan fixture depicting a troffer shelf;

FIG. 4 is a sectional view of one embodiment of the combination light and fan fixture of another embodiment depicting an alternative embodiment of a troffer shelf;

5

FIG. 5 is a sectional view of one embodiment of the combination light and fan fixture depicting an angled shell showing the flow of air;

FIG. 6 is a sectional view of an alternative embodiment of the combination light and fan fixture depicting another embodiment of the angled deflection mechanism;

FIG. 7 is a sectional view of yet another alternative embodiment of the combination light and fan fixture with the LED lighting fixture positioned in an indirect lighting configuration.

FIG. 8 is a perspective view of the embodiment shown in FIG. 7;

FIG. 9 is a perspective view of an embodiment of the present invention utilizing multiple round grills;

FIG. 9A is a perspective view of the fan grate depicted in FIG. 9;

FIG. 10 is a perspective view of an embodiment of the present invention utilizing a single grill and lens;

FIG. 10A is a perspective view of the fan grate depicted in FIG. 10;

FIG. 11 is a view of the present invention incorporating multiple fan blades;

FIG. 11A is a view of the present invention incorporating multiple fan blades;

FIG. 12 is a perspective view of an axial fan of the present invention;

FIG. 13 is a bottom view of one embodiment of the combination light and fan fixture;

FIG. 14 is a bottom view of an alternative combination light and fan fixture having 4 LED lights;

FIG. 15 is a bottom view of a ceiling tile having intake fans, exhaust vents, and LED lighting;

FIG. 16A is a cross section of a ceiling tile having a fan which directs air into a first and second airway;

FIG. 16B is a cross section of a ceiling tile having a UV light source for irradiating air flow through an airway;

FIG. 17 is an exploded view of components of a ceiling tile having two fans, two LED lighting strips, and an upper baffle for defining airways.

FIG. 18 is a bottom view of a ceiling tile having intake fans, exhaust vents utilizing a UV light source for irradiating air flowing through the chambers;

FIG. 19 is a perspective view of a ceiling tile having intake fans, exhaust vents utilizing a UV light source for irradiating air flowing through the chambers;

FIG. 20(a) is a cross section of a ceiling tile having a UV light source for irradiating air flow through a chamber, a raw intake, exhaust vents and various baffles; and

FIG. 20(b) is a cross section of a ceiling tile having a UV light source for irradiating air flow through a chamber, a raw intake, exhaust vents and baffles with a reflective material.

#### DETAILED DESCRIPTION OF THE INVENTION

Embodiments of the present invention may comprise a combination of a fan and LED light fixture. FIGS. 1 and 2 show side sectional views of an embodiment of the present invention depicting a troffer shelf 12. FIG. 3 shows a perspective view of an embodiment having a troffer shelf. The combination fan 10 may include a troffer shelf 12 which supports at least one LED light fixture 20 and a fan 30. The fan 30 is supported by a louvered fan support 18. As shown in FIG. 3, the louvered fan support 18 has a lower solid portion 19 and an upper open portion 17 that includes several opening and louvers 60 which direct air from the fan chamber 13 along the troffer shelf 12. It is not material to the

6

present invention where the solid portion 19 and open portion 17 is located in the fan support 18. What is important is that there is a solid portion 19 of the fan support 18 that braces the fan 30, and an open portion 17 that is configured to permit air to flow from the fan chamber 13 to the troffer chamber 16. The direction of the air flow is not necessarily important to the present invention. What is important is that the fan 30 causes air to flow in the vicinity of an LED light fixture 20.

The troffer shelf 12 may have the same general dimensions as a ceiling tile typically 1 ft.x2 ft., 2 ft.x2 ft. or 2 ft.x4 ft. The LED light fixture 20 is typically positioned along the troffer chamber 16 along the troffer shelf 12 such that light from the fixture 20 is not interrupted by the fan 30. The LED light fixture 20 may include an LED lamp 22. The LED light fixture 20 is preferably in the form of a strip which runs the length of the troffer shelf 12. The LED light fixture 20 is secured to the troffer shelf 12 in such a manner to permit air to flow along a substantial portion of the surface area of the LED lamp 22 and light fixture 20. The LED light fixture 20 may include a magnetic attachment mechanism to secure the light fixture 20 to the troffer shelf 12. The magnetic attachment mechanism serves multiple purposes including the ability to detach the LED light fixture 20 from the troffer shelf 12 in a relatively easy fashion. The magnetic attachment mechanism further serves to provide a space between the LED light fixture 20 and troffer shelf 12 for air to flow through which increases the surface area of the LED light fixture 20 that contacts the air. The greater the surface area of the LED light fixture 20 that comes in contact with the air flow, the faster and more efficient the temperature reduction of the LED light fixture. While LED light fixtures are discussed throughout this disclosure, it is understood that other types of lights may be utilized in the invention and benefit from the features of the invention.

The fan 30 preferably includes at least an axial fan as shown in FIG. 12. Referring back to FIGS. 1, 2 and 3, there may be more than one fan within the fan area 13. The blades 32 of the fan 30 force air to move parallel to a shaft 34 about which the blades 32 rotate. Air flow 40 moves axially through the intake of the fan 36 and axially out through the outlet 38 of the fan 30. The flow of air is generally linear through the intake 36 and the outlet 38. The design of the fan 30 is a function of the blade configuration 32 that creates a pressure of differential that produces airflow 40 across the fan blade 32. The fan 30 may consist of anywhere from 2 to 8 blades. The fan 30 is connected to a motor 51 and typically operates at high speeds. The typical speed of the axial fan of the present invention operates between 1800 to 4000 RPM to produce airflow in the range of 85 to 150 cubic feet per minute. While an axial fan is disclosed in the figures of the invention, it is understood that other types of fans such as a bladeless fan, cross-flow fan, or impeller-type fan may be used as the fan 30 in the embodiments shown in the figures. Any of those types of fans can be utilized without having a detrimental effect on the function and features of the invention. The important feature of the fan 30 is to move and distributes air within the fan area, regardless of the type of fan that was used.

As shown in FIG. 2, the configuration of the troffer shelf 12 directs the flow of air from the outlet 38 of the fan 30. Air flows along the troffer shelf 12 and the troffer baffle 14, along the LED light fixture 20. Air passing along the LED light fixture 20 acts to dissipate heat produced by the LED light fixture 20 which reduces the operating temperature of the LED light fixture 20. In essence, the air flow reduces waste heat produced by the LED fixture 20 by conducting

the heat away from the fixture **20**. It is believed that the airflow in the current invention can reduce the temperature of the LED light fixture from approximately 120° F. to approximately 80° F. in the typical environment found in offices, hospitals, retail stores, educational institutions and the like.

FIGS. **1**, **2** and **3** depict a combination LED light fixture and fan **10**. The air exiting the outlet **38** of the fan **30** is propelled into the fan chamber **13**. The air in the fan chamber **13** as shown in FIG. **3**, is directed by a diversion mechanism **50** so that the air flows through openings **17** in the fan support **18**. The air flowing through the opening **17** is directed by louvers **60** into the light chamber **16**, along the troffer shelf **12**, to engage the LED light fixture **20**. By directing air from the fan **20** along the troffer shelf **12** causes the air to circulate around the LED light fixture **20** to reduce the temperature of the light fixture **20**. The air flow in the lighting chamber **16** is directed by the troffer baffle **14** through an exit vent **84** formed by the damper **81**.

In embodiments of the present invention, there may be a vent and lens bracket **80**. The bracket **80** is affixed to the troffer shelf **12** in such a manner to permit air to flow from the light chamber **16** through an exit vent **84** formed by a damper **81** in the bracket **80**. The vent **84** permits the air heated by LED light fixture **20** to exit the light chamber **16**. The bracket **80** also includes a lens bracket **82**. The lens bracket **82** corresponds with a fan lens bracket **83** to secure a lens **90** in place within the combination LED light and fan **10**. The lens **90** provides a solid surface to assist with containing any air from the fan **30** such that it proceeds along the troffer shelf **12** and the troffer baffle **14** to the LED light fixture **20** and through the vent **84**. A lens **90** is not necessary to the invention. However, the lens **90** typically made of a somewhat flexible translucent plastic material. There is a mounting mechanism **100** that is used to affix the combination LED light fixture and fan to an adjacent ceiling tile or bracket.

Some embodiments of the present invention may incorporate the use of color displayed by the lighting system to affect the environment in which the combination LED light and fan fixture **10** may be implemented. Research has shown that different colors appear to affect behavioral traits in humans. For example, the color yellow is believed to influence a person's self-confidence; the color red is believed to influence a person's physical body, the color blue is believed to influence a person's mind and the color green is believed to influence a person's emotional balance. It is believed that, for example, the combination of a yellow color with a blue color will stimulate a person's emotional balance and mind. The different color combinations may be incorporated into the present invention in numerous ways. In one embodiment of the present invention, the colors blue, red, yellow or green may be applied to the internal surface of the troffer shelf **12** and/or the troffer baffle **14** by means of paint, insert or other known technique. Alternatively, the lens **90** may comprise of the colors blue, red, yellow or green. The colored lens **90** operates to transmit light of the lens color in an indoor space. Finally, the LED light fixture **20** itself may be configured to generate light in the blue, red, yellow or green spectrums by means of the LED lamp **22**.

The air exiting from the fan cavity **16** is directed along an airflow surface on the troffer shelf **12** and troffer baffles **14** air may alternatively be directed through a cooling chamber, which is not shown but functions to cool the fan components, as well as, the LED lighting components. The internal surface of the troffer shelf **12** and troffer baffles **14** may be coated with a Miro-Micro Matt wet paint produced by

Alanod. The paint helps to maintain airflow along the surface, as well as, maintain a clean dust-free surface. The airflow **40** has two general components. The air that exits the fan cavity **13** generally has a laminar flow along the airflow surface of the troffer shelf **12**. As the flow of air from the fan **30** extends towards the exterior perimeter of the troffer shelf **12** and troffer baffles **14** through the vent **84**, the flow becomes more turbulent and mixes with the surrounding air. The preferred direction of the air-flow is such that the intake **36** of the fan **30** draws air from the lower portion of a space and distributes the air along the upper portion of the space. Air along the lower portion of an area tends to be cooler than air that resides at the upper portion of an area. The cooler air is pulled into the fan **30** and distributed from the cavity is used to cool and clean the LED light fixture **20**, and/or the LED light bulb **22**.

The combination fan of the present invention may utilize the stepped-fan blade design depicted in the pending patent application Ser. No. 14/814,161, 15/043,923 and 15/346,913, each of which is hereby incorporated by reference, in the entirety. The benefits of the stepped-blade design are set-forth in detail in the pending patent applications referenced herein and need not be repeated in this provisional application and are not shown in the drawings. The stepped-fan blade design greatly improves the air flow characteristics of the fan **30**.

As shown in FIGS. **9**, **9A**, **10** and **10A**, the fan intake **36** may include decorative perforations and/or a grill **39**. The grills **39** may be of a circular configuration as shown in FIGS. **9** and **9A**. Alternatively, the grill may extend the length of the fan intake **36** as shown in FIGS. **10** and **10A**. The air intake **36** may also include a filter (not shown). Alternatively, the filter may be positioned at the air outlet **38** or at a grill covering the combination fan **39**. The filter serves to clean air flowing through the fan of dust and other fine particles. The filters may be removed for cleaning or replacement on a periodic basis. The embodiments shown in FIGS. **10** and **10A** are more adapted to accommodate a filter.

In some embodiments of the inventions, the combination fan and LED light system further includes an air diversion mechanism **50**. The air diversion mechanism **50** is positioned within the cavity of the fan chamber **13**. The physical configuration of the air diversion mechanism **50** is such that it directs air exiting the fan outlet **38** through the louvered openings **17** or diffuser in the louvered fan holder **18**. In some embodiments, the air diversion mechanism **50** is in the shape of a prism as shown in FIGS. **1** through **7**. Alternatively, the air diversion mechanism **50** may be in the shape of a pyramid (FIG. **8**), cone, pentagon, triangle or other suitable shape to divert air from the fan chamber **13**, through the openings **17** and into the troffer chamber **16** along the LED light fixture **20**. The air diversion mechanism directs air towards opening **17** along louvered vents **60** positioned along the inside fan chamber **13**. The vents **17** may include louvers **60** to assist in directing the air in the desired direction. Positioned within the air diversion mechanism **50** is a ballast housing **51** for LED lighting ballast, drivers and wires. The ballast housing **51** houses the wiring for both the LED lighting system and the fan to allow for a single hook-up to the electrical outlets or connections positioned within the ceiling.

The air exiting from the fan cavity **13** is directed along an airflow troffer shelf **12** to the troffer baffle **14**. Air may alternatively be directed through a cooling chamber, which is not shown, but functions to cool the components located in the ballast housing **51**, as well as, the LED lighting components.

As shown in FIG. 2, air 40 enters the fan 30 and is expelled by the fan blades 32 into the air chamber 13. Air flow in the fan chamber is generally laminar. Air is forced into the air chamber 13 and is directed by a louvre 60 through an opening in the fan chamber 13 into the light chamber 16. The air (shown in arrows) has generally a laminar flow along the troffer shelf 12 and troffer baffle 14. As the flow of air from the fan 30 extends towards the exterior perimeter of the housing in the vent 84, the flow becomes more turbulent and mixes with the surrounding air such that the air exiting through the damper 81 is more turbulent in nature. The preferred direction of the air-flow is such that the intake 36 of the fan 30 draws air from the lower portion of a space and distributes the air along the upper portion of the space. Air along the lower portion of an area tends to be cooler than air that resides at the upper portion of an area. The cooler air is pulled into the fan 30 and distributed from the cavity is used to cool and clean the LED light fixture 20, the LED cover 24 and/or the LED light bulb 22. In an alternative embodiment, the direction of the airflow may be reversed.

Turning to FIGS. 4, 5, 6 and 7, refer to alternative embodiments to the embodiment of FIGS. 1, 2 and 3. An alternative embodiment comprises a combination of a fan and LED light fixture. FIGS. 4, 5, 6 and 7 show views of different embodiments of the present invention.

FIG. 4 depicts an alternative design of the troffer shelf and the troffer baffle 14. In the alternative design, air is propelled from the fan 30 into the fan chamber 13. The air from the fan 30 is deflected by a diversion mechanism 50, through the opening 17 and directed by louvres 60 into the light chamber 16. The louvres 60 are configured to direct the air from the fan along the troffer shelf 12 and along the troffer baffles 14. By directing air from the fan 30 along the troffer shelf 12 causes the air to circulate along LED light fixtures 20. The air flow helps to reduce the temperature of the LED light fixture 20. The air flow is directed by the troffer baffle 14 through an exit vent 84 formed by the damper 81, in the lens bracket 80.

In FIG. 4, the troffer shelf 12 has more of a squared-shape. The troffer shelf 12 and the troffer baffle 14 intersect at generally right angles to each other. The fan 30 is positioned in generally the same position as demonstrated in FIG. 3. The fan chamber 13 includes a diverter 50 to direct air exiting the fan 30 through the open portion 17 of the fan chamber 13. Louvers 60 direct the air passing through the open portion 17 of the fan chamber 30 into the light chamber 16. Air flows along the troffer shelf 12 and the troffer baffle 14 passed the LED light fixture 20. Air passing along the light fixture passes along the plurality of LED light fixture 20 to dissipate the heat in the LED light fixture 20. The air follows a path along the air baffle through the vent 84 out of the light chamber 16.

The bracket 80 includes a damper 81 and lens bracket 82. The embodiment includes a lens 90 which acts to diffuse the light emitted from the LED lights 20. There is a mounting mechanism 100 used to affix the combination LED light fixture and fan to an adjacent ceiling tile or bracket.

The interior surface of the troffer shelf 12 and troffer baffle 114 may be coated with a Miro-Micro Matt wet paint produced by Alanod. The paint helps to maintain airflow along the surface, as well as, maintain a clean dust-free surface. The paint can be applied in any of the colors discussed above to affect the environment.

As shown in FIGS. 5 and 6, the combination fan 110 includes a housing 112 which supports at least one LED light fixture 120 and a fan 130. The housing is the same dimen-

sions as a ceiling tile typically 2 ft.x2 ft. or 2 ft.x4 ft. The LED light fixture 120 is preferably positioned along the periphery of the housing 112 such that light from the fixture 120 is not interrupted by the fan 130. The LED light fixture includes an LED light bulb 122.

The alternative embodiments of the combination LED light fixture and fan 110 utilize an internal baffle 114. The internal baffle 114 serves to direct air within the troffer cavity 116 and provide support for the LED lighting 120. The embodiments depicted in FIGS. 5 and 6 include a fan 130 that directs air through a fan exit 138 in the fan chamber 113. The fan chamber 113 includes an air diverter 150 which may take on many different shapes, such as a prism shown in FIG. 5 or a trapezoidal shape shown in FIG. 6. Air from the fan chamber 113 is directed by the diverter 150 through the open portion 117 of the fan support 118. The air flowing through the open portion 117 of the fan support 118 is directed by louvres 160. As shown in FIG. 6, the air is directed by the louvres 160 into the baffle chamber 116 along the baffle 114 across the LED light 120. The air passing across the LED light 120 is directed by the baffle 114 through the exit vent 184.

In FIG. 5, the baffle 114 guides air flowing through the openings 117 in the fan chamber 113 (which is directed by the baffles) along the LED light fixture 120. The air serves to reduce the temperature of the LED light fixture 120 and extend the life of the fixture 120. The baffle 114 guides the air flow from the LED light fixture 120 through the exit vent 184.

The fan 130 preferably includes an axial fan. The blades 132 of the axial fan force air to move parallel to a shaft 134 about which the blades 132 rotate. The flow of air 140 is axially through the intake of the fan 136 and axially out through the outlet 138 of the fan 130. The flow of air is linear through the intake 136 and the outlet 138. The design of the fan 130 is a function of the blade configuration 132 that creates a pressure of differential that produces airflow 140 across the fan blade 132. The axial fan 130 may consist of anywhere from 2 to 8 blades. The axial fan 130 is connected to an energy source (not shown) and typically operates at high speeds. The typical speed of the axial fan of the present invention operates between 1800 to 4000 RPM to produce airflow in the range of 85 to 150 cubic feet per minute. The combination fan of the present invention may utilize the stepped-fan blade design depicted in the pending patent applications referenced above.

The fan intake 136 of FIGS. 5 and 6 may include decorative perforations and/or a grill as shown in FIGS. 9 and 10. The air intake 136 may also include a filter (not shown). Alternatively, the filter may be positioned at the air outlet 138 or at a screen covering the combination fan 142. The filter serves to clean air flowing through the fan of dust and other fine particles.

One embodiment of the combination fan and LED light system 110 further includes an air diversion mechanism 150. The air diversion mechanism 150 is positioned within the fan chamber 113 of the fan 130. Looking at FIG. 14, the air diversion mechanism 150 is in the shape of a prism as shown in FIGS. 5, 6 and 13. Alternatively, the air diversion mechanism 150 may be in the shape of a pyramid (FIG. 14), cone, pentagon, triangle or other suitable shape to divert air to the LED components and into the office space. The air diversion mechanism 150 directs air towards vents 117 positioned along the fan cavity 113. The vents 117 may include louvres 160 to assist in directing the air in the desired direction. Additionally, the air diversion mechanism may have vents to

permit a portion of the air circulated by the fan to enter the diversion mechanism **150** to provide a cooling effect on the ballast housing **151**.

The air exiting from the fan cavity **116** is directed along an airflow surface on the troffer baffle **114** air may alternatively be directed through a cooling chamber, which is not shown but functions to cool the fan components, as well as, the LED lighting components. The internal surface of the troffer baffle **114** is preferably coated with a Miro-Micro Matt wet paint produced by Alanod. The paint helps to maintain airflow along the surface, as well as, maintain a clean dust-free surface. The airflow **140** has two general components. The air that exits the fan cavity **113** generally has a laminar flow along the airflow surface of the lower housing portion **114**. As the flow of air from the fan **130** extends towards the exterior perimeter of the housing **112** through the vent **184**, the flow becomes more turbulent and mixes with the surrounding air. The preferred direction of the air-flow is such that the intake **136** of the fan **130** draws air from the lower portion of a space and distributes the air along the upper portion of the space. Air along the lower portion of an area tends to be cooler than air that resides at the upper portion of an area. The cooler air is pulled into the fan **130** and distributed from the cavity is used to cool and clean the LED light fixture **120**, and/or the LED light bulb **122**.

An embodiment of the combination LED light fixture and fan **200** in which the LED light fixtures **220** are directed toward the ceiling is depicted in FIGS. **7** and **8**. The combination LED light fixture and fan **200** in FIG. **7** includes a fan **220**. The fan **230** may include an invented axial fan, or any fan that serves the purpose of distributing air in a relatively quiet fashion. The fan **230** includes an air inlet **236** and air exit **238**. There is a fan chamber **216**. Air is drawn from the indoor environment, through the air inlet **236** and propelled by the fan through the fan exit **238** into the fan chamber **213**. There is a diverter **250** positioned within the fan chamber **213** to direct air from the fan through an open portion **117** of the fan support **218**. The open portion **217** may include louvers **260** to guide the air from the fan chamber **213** into a troffer cavity **216**.

The combination LED light fixture and fan **210** has a domed shell **292**. While a domed-shaped shell **292** is shown in some embodiments, any shaped shell may be utilized and still practice the invention. The shell **292** serves as a troffer. The shell **292** is configured to direct air from the troffer cavity **216** along the LED light fixtures **220** and through the exit vent **284**. A lens **290** is positioned on top of the shell **292**. The LED light fixtures **220** may be configured to direct light upward toward the ceiling or downward toward the shell **292**. The shell **292** may be made of a solid material or alternatively a translucent material to permit light to penetrate the shell **292** into the room. The combination LED light fixture and fan **220** is supported from the ceiling by one or more mounting cables **294**. The mounting cables **294** may be configured to accommodate power cables to supply power to the fan **230** and LED light fixtures **220**.

The combination LED light fixture and fan as shown in all the embodiments of the present invention may use a hard-wired control mechanism to control both the light **20** and fan **30**. The invention may use an ethernet connection and remote control to activate the fan **30** and LED light fixture **20**. Alternatively, a wi-fi (wireless) connection may be used in connection with a remote control to control the LED light **20** and fan **30**. The remote control feature is configured to adjust the intensity (or color) of the LED light fixture **20** and the speed of the fan **30**.

The embodiments of the inventions shown in FIGS. **1** through **7** show a fan that is independent from the HVAC system of the building in which the combination LED lighting fixture and fan **10** may be installed. However, it is contemplated that the combination LED lighting fixture and fan **10** may be combined with the existing HVAC system in order to distribute the air from the HVAC system through fan chamber **13** and through the light chamber **16**. The combination LED lighting fixture and fan **10** may be the primary source of distribution of the air from the HVAC system or it could be use in a supplemental capacity. If the HVAC system is implemented in connection with the combination LED light fixture and fan **20**, the HVAC system could be connected to the combination LED light fixture and fan **10** at several locations. For example, the HVAC system could be configured to delivery air from the HVAC system into the fan chamber **13** or the light chamber **16** by connecting a duct from the HVAC system to either the fan chamber **13** or the troffer cavity. The fan **30** of combination LED light fixture and fan **10** provides a supplemental air delivery system to augment the HVAC system.

As shown in FIGS. **11** and **11A**, the combination fan may include two or more fans **30**. In the multiple fan configuration, it is beneficial that adjacent fans rotate in different directions to provide a more even distribution of air along the fan **30**. It is important to note that the adjacent fans rotate in opposite directions. As shown in FIG. **11A**, the multiple fans may all rotate in the same direction.

FIG. **12** depicts a fan **30** and **130** that may be used in embodiments of the inventions.

Various aspects of this disclosure may include components which are implemented directly into a ceiling grid, or ceiling tile, as seen for example in FIG. **15**. It is contemplated that an exemplary ceiling tile **1501** may be sized as 1'x4'; 2'x2'; or 2'x4', although a person of skill in the art would understand that any appropriately sized ceiling tile may be used in accordance with the present inventions. Moreover, ceiling tile **1501** could be acoustical, fiber, wood, metal, translucent, plastic, sheet rock, or drywall structures as are known to be used in industrial, commercial, or residential environments.

In embodiments of the inventions, ceiling tile **1501** may have one or more fans **1502** and vents **1503** cut into the ceiling tile **1501**, sometimes referred to herein as a ceiling panel. Panel cuts may be made or manufactured using waterjet cutting, die cutting, laser cutting, CNC routing, CNC knife cutting, reciprocated knife cutting, or any other known techniques for cutting through tiles. Vents **1503** may take the form of elongated slot(s) extending near the edge of ceiling tile **1501**, although other shapes are also contemplated. For example, FIG. **15** shows two elongated vents on the ceiling tile **1501**'s top edge, and two additional vents along the bottom edge. A person of skill in the art would understand that additional arrangements are contemplated. Optional LED strips **1504** may be included and may extend between the one or more fans **1502** and vents **1503**.

As seen in FIG. **16A**, which is a cut-away side view of embodiments of the inventions, an upper baffle **1610** and one or more lower baffles **1620**, **1621**, may act together to define one or more airway(s). For example, air may pass from a fan **1502**, along airway(s) **1630**, **1631** (e.g. a first airway to the left and a second airway to the right), to vents **1503**. Upper baffle **1610** may comprise an apex portion **1615** which is formed in close proximity to fan(s) **1502** and/or **1503**. Embodiments in which an apex portion **1615** extends into proximity with fan(s) **1502** and/or **1503** provide the advantage of improved airflow: that is because apex portion **1615**

forces air to split evenly towards the left and right side. In the absence of apex portion **1615**, the direction of rotation of fan(s) **1502** and/or **1503** may lead to uneven air distribution. The apex portion **1615** performs a similar function to air diversion mechanism **50** described above. Indeed, a person of skill in the art would recognize that the air diversion mechanism **50** (See e.g. FIG. 1) may be included in the embodiment of FIG. 16. Preferably, fan(s) **1502** take in air, which is released out through vents **1503**. In such an arrangement, fan(s) **1502** act as an air intake and vents **1503** act as an exhaust. A person of skill in the art would recognize that it is also possible for fan(s) **1502** and/or **1503** to be configured to act as an exhaust, rather than an intake. In embodiments where LED strips are included, the flow of air through airways **1630** and **1631** may act to cool the LED strips **1504**. Where two or more fans **1502** are included in an embodiment, it may be desirable, as already described above, to have them rotate in opposite directions relative to one another, e.g. one may spin clockwise while the other spins counterclockwise.

Embodiments of the invention further include the functionality of irradiating germs out of the air using UV light. Such embodiments provide the advantage of not only circulating air in an environment, but also killing viral, bacterial, and fungal species which may be living in the environment's air. It is known the UV light degrades organic materials, but inorganic materials (including metals or glass) are not affected by UV light. Therefore, UV light is effective for reducing organic matter which may be airborne in the air. Reducing airborne contaminants may be important in any environment, but especially in hospitals or schools, which may be particularly susceptible to disease. Regardless of the environment, disinfecting the air of contaminants is helpful to reduce the spread of disease.

It is preferable to reduce or eliminate contact with UV lighting because UV light can be harmful to humans and/or animals (particularly over prolonged durations). Embodiments of the invention therefore provide the advantage of positioning a UV light source in the ceiling tile, where the UV rays may be contained in the ceiling tiles. For example, FIG. 16B illustrates exemplary UV light source(s) **1640** which are mounted inside the upper baffle **1610** and thus irradiate organic matter residing in air as air flows from the fan to the vent. A person of skill in the art would recognize that UV light sources include a power source and may optionally include an on/off controller (not shown). The UV light source may be activated by an on/off button, or it may be controlled by the remote control feature described further herein. In such an embodiment, a remote control may include the ability to activate or de-activate a UV light source.

In some embodiments, light source(s) **1640** may emit UVC light, which has a wavelength of approximately 200 to 280 nanometers. A person of skill in the art would recognize the UVC light is optimal for irradiating airborne contaminants (such as viruses, superbugs, mold, and the like) in most environments. In embodiments of the invention, the upper baffle **1610** and/or the lower baffle **1620/1621** may be made of, or coated with, a UV-reflective material. A person of skill in the art would recognize that a UV-reflective material could include a metal, such as stainless steel, or a specialty coating. Lining the airway with a reflective material and/or reflective coating provides the advantage of creating a "kill chamber," or "kill zone" inside the airways **1630**, **1631**, where UV rays may bounce to increase their

exposure to air passing through the airways **1630**, **1631**, and by extension, increase the irradiation of organic matter contained in the air.

Furthermore, some embodiments of the inventions may include a UV-screen in the form of flange **1650** which is attached to the end of airways **1630** and/or **1631** to shield UV rays from exiting the airways and entering an environment (such as a room or commercial space). In this way, including UV-screen(s) **1650** at the end of an airway Although FIG. 16B illustrates a UV source in an embodiment which is built into a ceiling tile, it should be understood that the disclosed UV source and "kill chamber" may be implemented in any of the embodiments disclosed herein.

FIG. 17 shows an exploded view of components of the invention. For example, the embodiment of FIG. 17 shows a ceiling tile **1501** in which there are cut-outs for fans **1502** and vents **1503**. Upper baffle **1610** is shown, sized to fit onto ceiling tile **1501**. Furthermore, FIG. 17 shows exemplary LED strips **1504** (including power cord) which may be mounted on the ceiling tile **1501**'s underside.

Various aspects of this disclosure may include components which are implemented directly into the ceiling grid, or ceiling tile **1801**, as seen for example in FIG. 18. It is contemplated that an exemplary ceiling tile **1801** may be sized as 1'x4', 2'x2' or 2'x4', although a person skilled in the art would understand that any appropriately sized ceiling tile may be used in accordance with the present inventions. Moreover, ceiling tile **1801** could be acoustical, fiber, wood, metal, translucent, plastic, sheet rock, or drywall structures as are known to be used in industrial, commercial, or residential environments. Alternatively, the ceiling grid **1801** may take the form of a light fixture that fits within the ceiling tile grid.

In embodiments of the inventions, ceiling tile **1801** may have one or more fans **1802** and vents **1803** cut into the ceiling tile **1801**, or positioned in the ceiling grid, sometimes referred to herein as a ceiling panel. Panel cuts may be made or manufactured using waterjet cutting, die cutting, laser cutting, CNC routing, CNC knife cutting, reciprocated knife cutting, or any other known techniques for cutting through tiles. Vents **1803** may take the form of elongated slot(s) extending along the edge of ceiling tile **1801**, although other shapes are also contemplated. For example, FIG. 18 shows an elongated slot **1803** that runs along the entire length of the tile **1801**. A person of skill in the art would understand that additional arrangements are contemplated. Optional LED strips (not shown) may be included, and may extend between the one or more fans **1802** and vents **1803**.

As seen in FIG. 20A, which is a cut-away side view of embodiments of the inventions, upper baffles **2010**, **2011** and one or more lower baffles **2020**, **2021**, may act together to define one or more airway(s). For example, air may pass from a fan **2002**, along airway(s) **2030**, **2031** (e.g. a first airway to the left and a second airway to the right), to vents **2003**. Upper baffles **2010**, **2011** may form air deflection mechanism **2015** which is formed in close proximity to fan **2002**. Alternatively, the deflection mechanism **2015** may consist of a separate structure. Embodiments in which an air diversion mechanism **2015** extends into proximity with fan **2002** provides the advantage of improved airflow: that is because the air diversion mechanism **2015** forces air to split evenly towards the air chambers **2030** and **2031**. In the absence of air diversion mechanism **2015**, the direction of rotation of fan **2002** may lead to uneven air distribution. The air diversion mechanism **2015** performs a similar function to air diversion mechanism **50** described above. Indeed, a person of skill in the art would recognize that the air

diversion mechanism **50** (See e.g. FIG. 1) may be included in the embodiment of FIGS. **20A** and **20B**. Also included within the air flow airways **2030** and **2031** are a series of baffles **2040**, **2042** and **2044**. The baffles operate to direct the air flowing through the airways **2030** and directs the air through an outlet vent **2003**. The baffles **2040**, **2042** and **2044** form what is called the kill zone. There may be included in the embodiment shown in FIG. **20A** are UV light systems **2060**. The UV lights **2060** operate to irradiate fungi, bacteria and viruses form the air circulating through the system **2001**. The UV lights operate within a wavelength of approximately 200 to 280 nanometers. The bulbs used in the UV light are typically referred to the UV-C light spectrum. The UV-C bulbs operate along the specific wave length of ultra-violet lights or light diffusing optical fibers. The UV-C light sources are typically referred to as T-5, T-8 or similarly type of LED lighting fixtures. The embodiment in FIGS. **20A** and **20B** may include an indicator light (not shown) to indicate when the UV-C light source is operating within the chambers **2030** and **2031**. While the UV-C light source is shown in FIGS. **20A** and **20B** the LED light **20** depicted in FIGS. **1-7**, **13** and **14** above could be replaced with the UV-C light source.

The UV-C lights **2060**, emitting light along a wavelength of 200 to 280 nanometers, have been deemed to have potentially harmful effects on humans. The baffles **2040**, **2042** and **2044** operate to maintain the light emitted by the UV-C light fixture **2060** within the fixture so that little, if any, UV-C light is emitted from the fixture through the fans **2002** or the vent **2003**. The baffles **2040**, **2042** and **2044** may be positioned on the opposite side of the airway **2031**. Preferably, fan(s) **2002** take in air, which is released out through vents **2003**. In such an arrangement, fan(s) **2002** act as an air intake and vents **2003** act as an exhaust. A person of skill in the art would recognize that it is also possible for fan(s) **2002** and/or **2003** to be configured to act as an exhaust, rather than an intake. In embodiments where UV-C lighting is included, the flow of air through airways **2030** and **2031** may act to irradiate the air to eliminate germs, viruses, bacteria, fungi or the like. Where two or more fans **2002** are included in an embodiment, it may be desirable, as already described above, to have them rotate in opposite directions relative to one another, e.g. one may spin clockwise while the other spins counterclockwise.

In the embodiment shown in FIG. **20B**, the light source(s) **2060** may emit UVC light, which has a wavelength of approximately 200 to 280 nanometers. A person of skill in the art would recognize the UVC light is optimal for irradiating airborne contaminants (such as viruses, superbugs, mold, bacteria, fungus and the like) in most environments. In embodiments of the invention, the upper baffle **2010** and/or the lower baffle **2020** and **2021** may be made of, or coated with, a UV-reflective material. A person of skill in the art would recognize that a UV-reflective material could include a metal, such as stainless steel, or a specialty coating. Lining the airway with a reflective material and/or reflective coating provides the advantage of creating a "kill chamber," or "kill zone" inside the airways **2030** and **2031**, where UV rays may be deflected within the kill chamber to increase their exposure to air passing through the airways **2030** and **2031**, and by extension, increase the irradiation of organic matter contained in the air. Furthermore, in the embodiment of FIGS. **20A** and **20B**, the baffles **2040**, **2042** and **2044** located in airways **1630** and/or **1631** operate to (1) shield UV rays from exiting the airways and entering an environment (such as a room or commercial space) and (2) to increase the intensity the air is exposed to the UV-C light

emitted by the UV-C light source **2060**, and (3) increase the duration of air flowing through the airway **2030** and **2031** is exposed to the UV-C light. The baffles **2040**, **2042** and **2044** operate to extend the time that the air flows along the kill zone thus increasing the number of germs that are killed within the fixture. An actual test of a unit utilizing the UV-C light source **1640** was conducted. The study was conducted to verify the unit's microbial reduction efficacy of aerosolized contaminants. The unit was mounted on the ceiling in a sealed 11' 10"×11' 10"×8'1" (1125 cu-ft) controlled environment room. The unit's fan and UV lamps were powered on and allowed to warm up over the course of 2-hours as part of conditioning. Aliquots of the microorganisms were added to a pre-sterilized nebulizer reservoir. The testing room was sealed; all equipment activation was performed remotely. The nebulizer was powered to aerosolize the microbial suspension. Following 5 minutes, the UV-C light source and fans were powered on. Samples of the air were collected immediately after unit activation using Bio-aerosol air impinger (Biosampler, SKC, Inc.). The air samples were collected over the course of three minutes. Air samples were collected again following 1 and 2-hours following start. The system was deactivated, and the room was exhausted for 25 minutes before entry for sample retrieval and subsequent analysis. The study was repeated as described with only the fans running and then again with the unit completely powered off. All collected samples were analyzed in triplicate at the minimum as per standard lab operating procedures. Analysis was conducted as per laboratory's accredited ISO17025: 2005 methodology: bacteria were analyzed as per SM 9215 (APHA 2012) and MS-2 as per EPA 1602. Analysis was conducted using calibrated and/or validated Instruments to traceable standards (NIST). All QC was within method acceptance limit. No general environmental conditions are specified in the standard or have been identified that could affect the test results or measurements.

The test results demonstrated the following:

The test resulted in a finding that 99.6% of *K. pneumoniae* was eliminated from the air after 1-hour of operation, and 99.998% of *K. pneumoniae* was eliminated from the air after 2-hours of operation. There was a 30% reduction of *K. pneumoniae* from the air after 1-hour of operation when the UV light source was not activated. The tests further found that 98.4% of the MSZ virus was eliminated from the air after 1-hour of operation and 99.6% of the MSZ virus was eliminated after 2-hours of operation. There was a 27.2% reduction of MSZ virus from the air after 1-hour of operation when the UV light source was not activated.

While specific combinations of elements are disclosed in specific embodiments, it should be understood that any combination of the different features may be utilized in the combined fan.

The foregoing disclosure and description of the invention are illustrating and explanatory thereof, and various changes in the size, shape and materials as well as in the details of illustrated construction may be changed without departing from the spirit of the invention.

It is understood that the invention is not limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

What is claimed is:

1. An air purifying device, comprising:  
a ceiling tile having at least one vent and one fan portion;

17

- an upper cover attached to the ceiling tile defining at least an airway between the fan portion and the vent;
- a fan positioned in the fan portion adapted to guide air to the airway;
- a UV light source mounted in the airway, wherein the UV light source is a UV-C light source emitting light having a wavelength between 200 and 280 nanometers;
- a first baffle positioned in the airway and a second baffle positioned in the airway, wherein the first baffle and second baffle are configured to direct air guided by the fan to the airway along the UV light source; and wherein the first baffle and the second baffle are positioned in the first airway to act as a barrier preventing light emitted from the UV light source from exiting the air purifying device.
- 2. The air purifying device of claim 1, wherein the first baffle accommodates a UV reflective material.
- 3. The air purifying device of claim 2, wherein the second baffle accommodates a UV reflective material.
- 4. The air purifying device of claim 1, wherein the cover includes a UV reflective material.
- 5. The air purifying device of claim 1, wherein the ceiling tile includes a UV reflective material.
- 6. The air purifying device of claim 4, wherein the ceiling tile includes a UV reflective material.
- 7. The air purifying device of claim 1, wherein the first baffle and second baffle create a kill zone which kills bacteria, viruses or microbes present in the air guided by the fan to the airway.
- 8. The air purifying device of claim 2, further comprising a second fan mounted to the fan portion of the ceiling tile and in-line with the first fan.
- 9. The air purifying device of claim 8, wherein the first and second fan are configured to rotate in opposite directions.
- 10. The air purifying device of claim 1, further comprising an LED light source affixed to the ceiling tile.
- 11. The air purifying device of claim 1, further comprising an actuator to control the operation of the UV light source.

18

- 12. The air purifying device of claim 11, wherein the actuator is a remote control unit.
- 13. The air purifying device of claim 1, further comprising an indicator light source providing a visual indication when the UV light source is operating.
- 14. An air purifying device comprising:
  - a face-plate configured the size of a ceiling tile, wherein the face-plate includes a fan portion and a vent portion;
  - a cover attached to the face-plate forming an air chamber between the face-plate and the cover;
  - a fan positioned in the fan portion of the face-plate, wherein said fan directs air through the air chamber to the vent portion;
  - a UV-C light fixture positioned in the air chamber wherein the UV-C light fixture emits UV light to form a kill zone within the air chamber; and
  - a baffle positioned in proximity to the kill zone in the air chamber wherein the baffle is configured to direct air to the kill zone and prohibit the UV light from exiting the kill zone.
- 15. The air purifying device of claim 14, further comprising a LED light positioned on the face-plate.
- 16. The air purifying device of claim 14, wherein the UV-C light source emits UV-C light waves having a wavelength between 200 and 280 nanometers.
- 17. The air purifying device of claim 16, wherein the UV-C light source operates to kill at least 99% of *K. pneumoniae* from the air.
- 18. The air purifying device of claim 14, further comprising a second baffle positioned in the air chamber attached to the housing and wherein the second baffle directs air to the kill zone.
- 19. The air purifying device of claim 14, wherein UV-C light fixture emits light capable of killing bacteria, viruses and microbes.
- 20. The air purifying device of claim 18, further comprising a third baffle positioned in the air chamber wherein at least one of the baffle or the second baffle accommodates a UV-reflective material.

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